NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND

TECHNICAL REPORT

REPORT NO: NAWCADPAX--99-74-TR

HUMAN PHYSIOLOGICAL RESPONSES TO PUSH-PULL ACCELERATION AS EXPERIENCED IN HELICOPTERS

13 July 1999

DEPARTMENT OF THE NAVY
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND

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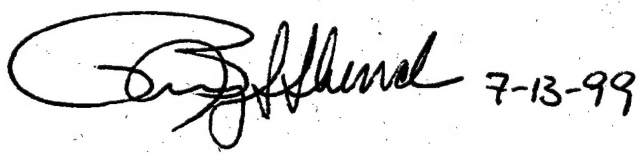
PREPARED BY:



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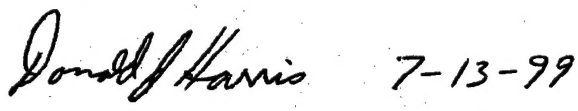

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	13 July 1999	Technical

4. TITLE AND SUBTITLE

Human Physiological Responses to Push-Pull Acceleration as Experienced in Helicopters

5. FUNDING NUMBERS

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)

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22347 Cedar Point Road Unit #6
Patuxent River, Maryland 20670-1161

8. PERFORMING ORGANIZATION REPORT NUMBER

NAWCADPAX--99-74-TR

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Air Systems Command
47123 Buse Road Unit IPT
Patuxent River, Maryland 20670-1547

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

NAWCAD Patuxent River assessed the risk to helicopter aircrew of acceleration stress by investigating the human physiologic response to transitions from -1 Gz (push) to +4.5 Gz (pull) loads. Nine volunteers participated in a human centrifuge study in which nine actual helicopter maneuvers were reproduced in a 1 hr mission scenario (push-pull mission (PPM)) which simulated both current (current mode (CM): -0.2 to +3.5 Gz) and future capabilities of U.S. Navy helicopters (future mode (FM): -1 to +4.5 Gz). Additional scenarios were run in which transitions < 1 Gz were fixed at +1 Gz. Blood pressure, loss of vision, and subjective fatigue were measured. Visual decrements were trivial during CM while muscular tensing was required to avoid blackout during FM. Subjects tolerated the range of Gz-stresses associated with current U.S. Navy platforms. When subjected to FM PPM G-loads (typical of current U.S. Army platforms), cardiovascular stress significantly increased, Gz tolerance dropped up to 1.2 g, and heart rate increased as much as 67 bpm. Four subjects reported Almost-Loss of Consciousness symptoms during FM. While G-stress experienced by aircrew generated by current helicopters does not appear to present a high risk, G awareness training is recommended to reduce risks to aircrew exposed to G-loads generated by more aggressive helicopters.

14. SUBJECT TERMS

Helicopter
G-stress
A-LOC
Simulation
Physiology

15. NUMBER OF PAGES

83

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

SUMMARY

NAWCAD Patuxent River assessed the risk to helicopter aircrew of acceleration stress by investigating the human physiologic response to transitions from -1 Gz (push) to +4.5 Gz (pull) loads. This includes the risk of G-induced Loss of Consciousness (G-LOC) or Almost-Loss of Consciousness (A-LOC). Seven men and two women volunteers participated in a human centrifuge study conducted at the North American Technology Center in Warminster, Pennsylvania, in which nine helicopter maneuvers (based on in-flight G measurements) were used to form a 1 hr mission scenario (push-pull mission (PPM)) which simulated both the current (current mode (CM): -0.2 to +3.5 Gz) and projected future capabilities of helicopters (future mode (FM): -1 to +4.5 Gz). Additional scenarios were run in which the sequence and timing were the same but excursions < +1 Gz were set to +1 Gz (+Gz mission (GM)). Measurements of head level blood pressure (BP), loss of vision, and subjective fatigue were taken. Data were then compared between the PPM and GM. While few subjects experienced light loss during the CM, muscular tensing was required to avoid blackout during FM. Light loss typically occurred during the transition from -Gz to +Gz. Systolic BP increased during transitions below +1 Gz and decreased above +1 Gz. Within the scope of these tests, subjects had little difficulty tolerating the range of acceleration stresses associated with platforms currently employed in the U.S. Navy inventory. When subjected to FM G-loads (within the capabilities of current U.S. Army platforms), cardiovascular stress significantly increased, Gz tolerance dropped as much as 1.2 g, and heart rate increased as much as 67 bpm. Cardiovascular changes were significantly greater during the FM PPM relative to GM. Four subjects reported A-LOC symptoms during FM. While G-stress experienced by aircrew generated by current helicopters does not appear to present a high risk, G awareness training is recommended to prevent A-LOC and G-LOC threats for aircrew exposed to G-loads generated by more aggressive helicopters. Future studies are required to determine the impact of longer mission times and dehydration.

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ACKNOWLEDGMENTS

The author would like to acknowledge contributions of the following people to the completion of this project:

- LTC John Crowley, U.S. Army, for providing the helicopter acceleration profiles.
- James Sheehy, Ph.D. and Estrella Forster, Ph.D. for their encouragement and support.
- Mr. Dennis Kiefer, Mr. Leland Donnen, Mr. Dave Bishoff, and Mr. L. Doug Waldman of Veridian Operations for their help with dynamic flight simulation operations.
- CDR David McGowan for providing the medical monitoring during this project.
- Volunteer test subjects for their invaluable assistance without which this project would have been impossible.

INTRODUCTION

BACKGROUND

1. Current sophisticated helicopters have the capability to generate and sustain acceleration forces as high as +4 Gz. Some two-seat platforms also have the capability to generate G-forces below 1 g. For example, the 1994-1995 edition of Jane's All the World's Aircraft lists the U.S. Navy/U.S. Marine Corps AH-1W Super Cobra (a range from +0.5 to +3.5 Gz - its rotors cannot withstand -Gz loads), the U.S. Army AH-64D Longbow Apache (a range from -0.5 to +3.5 Gz), and the U.S. Army RAH-66 Comanche (a range from -1.0 to +3.5 Gz). Note that helicopter aircrew are not trained to perform anti-G straining maneuvers and their garments do not incorporate G-protection. Table 1 lists the operational guideline for acceleration limits (not airframe limits) of several military helicopters.

Table 1
OPERATIONAL G-LIMITS OF SELECTED HELICOPTERS

Helicopter Operational Gz Limits		
Aircraft	Name	G-range
OH-58	Kiowa	+0.5 → +2.8
OH-58D	K Warrior	+0.5 → +2.8
AH-1	Cobra	+0.5 → +2.4
UH-60	Black Hawk	-0.5 → +3.0
AH-64	Apache	-0.5 → +3.5
RAH-66	Comanche	-1.0 → +3.5
BK-117	*	-0.2 → +3.0

*G-ranges for BK-117 were observed values during flight tests.

2. While these G-levels are relatively low when compared to fixed wing tactical aircraft, and helicopters cannot sustain G-loads for long periods of time (airspeed and rotor RPM bleed off), the nature of rotary wing missions presents a potential danger. Helicopter missions are typically flown at low altitudes, e.g., 50 ft AGL at 120 KIAS. At that height, G-induced symptoms which may lead to confusion, light loss, or may contribute to loss of or altered situational or spatial awareness can have catastrophic consequences.

3. A common problem in helicopter operations is heat stress associated with wearing protective garments and low level flight. Taliaferro, et. al. (reference 1), found that acceleration tolerance decreased by 8% when subjects were 1% dehydrated and by 16% when they were 3% dehydrated. Allan and Crossley (reference 2) found that relaxed (no anti-G suit or anti-G

straining) G-tolerance was reduced by +0.9 Gz when aural temperature increased by an average of 1.3°C. Under these conditions, even the relatively low +Gz-loads generated in rotary flight may present a safety hazard.

4. This hazard may be compounded during operations which include transitions from -Gz (push) to +Gz (pull) loads. The so called "push-pull" effect (PPE) derives from the situation during flight in which a pilot experiences a negative acceleration (< 1 g) along the seated body long axis (blood shifts towards the head and blood pressure (BP) rises) followed by a fairly rapid transition to positive acceleration (> 1 g) along the seated body long axis (blood shifts away from the head and BP falls). The reason for concern is that the negative acceleration reduces the body's cardiovascular tolerance to the ensuing positive acceleration. Pilots, unaware of a loss of tolerance, can lose and, in tactical aircraft, have lost consciousness at a level lower than their expected tolerance point.

5. This phenomenon is not new. The negative-to-positive G effect has been known since military powered flight began. Early flight surgeon manuals warned of the dangers of following negative G with positive G. Aerobatic flight maneuvers, such as the Vertical "8" maneuver, incorporated negative-to-positive G and pilots were lost when their aircraft "inexplicably" crashed during air shows (reference 3). Research into the effects of such transitions began in the 1950's by Von Beckh. In his first study (reference 4), he found that, during a transition from 0 to +6.5 Gz, subjects were disoriented, visual blackout lasted longer, and eye-hand coordination deteriorated. In a 1958 study (reference 5), nine subjects flew in a two seat Lockheed F-94C (51 missions overall) to determine the physiological reactions to acceleration loads from +4 to +6.5 Gz obtained by flying 40 to 60 sec "diving spirals" (continuous steep turns while losing about 10,000 ft in altitude) both preceded and succeeded by a 35 to 45 sec period of weightlessness produced by flying Keplerian ballistic trajectories. During the 0 Gz to +Gz maneuvers, subjects reported the same or greater discomfort during the +Gz phase as compared to the control runs. Two subjects who did not blackout during the control (+5 Gz) run, blacked out at +3.5 and 4 Gz; three who did blackout during control runs, blacked out at lower +Gz loads and at shorter G durations. One subject who had no visual symptoms during control, blacked out at +3.5 Gz and experienced G-induced Loss of Consciousness (G-LOC) at +5 Gz. Lehr, et. al. (reference 6), found that even a 2 sec -1 Gz exposure reduced relaxed +Gz-tolerance by about +0.77 Gz in centrifuge exposures. Prior, et. al. (reference 7), confirmed in flight that mean systolic BP (SBP) decreased after a transition from -2.5 to +4 Gz and, that while the fall in BP was unaffected by suit inflation, BP recovery was increased when the suit was activated.

6. To summarize, when humans are exposed to < 1 g, blood shifts towards the head. This increase in cephalad blood volume is sensed by the carotid baroreceptors which act to decrease heart rate (HR) to slow this shift. Other cardiovascular compensatory mechanisms which may be involved include changes in vasomotor tone to restrict the headward shift (reference 8). When -Gz-stress is followed by a +Gz-load, the ability of the body to compensate for the initial cardiovascular response (i.e., increased HR, decreased head level BP, increased lower body BP) may be delayed due to the relative -Gz-induced bradycardia. It is postulated that the potential danger of the PPE is two-fold: (1) the transition in and of itself could lead to G-LOC; and (2) the

event may contribute to a case of Almost-Loss of Consciousness (A-LOC) in which aircrew become confused and frustrated and may sometimes experience uncontrollable muscle tremors without losing consciousness.

7. It is unknown whether the loads generated in a helicopter will produce the same effect as in fixed wing aircraft. Furthermore, research into the PPE has focussed on study of the phenomenon as an isolated event, i.e., expose subjects to different -Gz and +Gz levels, durations, and G-transition rates as discrete runs, not as part of mission scenario. The truly relevant operational question is not only if an individual push-pull maneuver presents a G-LOC threat, but whether it contributes to decreased performance and critical physiological decrements over the course of an entire mission. This report addresses whether or not push-pull presents a physiologic problem in rotary wing aircrew by simulating helicopter mission scenarios which include transitions ranging from -1 to +4.5 Gz as well as solely +Gz maneuvers (at levels representing current and projected rotary wing capabilities) in the human centrifuge facility at the North American Technology Center in Warminster, Pennsylvania.

PURPOSE

8. The purpose of this study was to determine (1) the physiologic response to a simulated high performance helicopter mission scenario which features transitions in +Gz-loads (up to +4.5 Gz) as well as push-pull transitions in the range from -1 to +4.5 Gz and (2) the effect of cumulated Gz exposure on physiologic response during these conditions.

DESCRIPTION OF SUBJECTS AND EQUIPMENT

SUBJECTS

9. To achieve these objectives, two women and seven men were recruited to participate in this study. Subject characteristics and relaxed G-tolerance (no anti-G suits or anti-G straining) is given in table 2. Eye-heart distance was measured from the level of the aortic valve (third intercostal space) to the ectocanthus (reference 9). Informed consent was obtained from all subjects prior to the conduct of this investigation in accordance with SECNAVINST 3900.38B and all pertinent Department of Health and Human Services regulations. Subjects wore summer flight coveralls but no protective clothing (e.g., survival vest) other than a MA-2 torso harness.

Table 2
DESCRIPTION OF SUBJECTS

Subject Characteristics						
Subject No.	Weight (kg)	Height (cm)	Age (yr)	Gender	Eye-Heart Distance (cm)	Relaxed G-Tolerance (+Gz)
N1	93.0	177.8	38	M	29.4	4.0
N2	65.3	175.3	27	M	30.9	4.0
N3	69.4	170.2	28	M	32.2	3.5
N4	54.4	165.1	37	F	28.5	4.0
N5	54.9	165.1	32	F	29.0	5.0
V1	82.1	177.8	34	M	28.5	3.5
V2	65.8	167.6	32	M	26.7	5.0
V3	74.8	170.2	29	M	26.8	5.5
V4	74.8	180.3	35	M	27.7	4.0

MEASURES

10. Subjects were outfitted with two sets of electrocardiographic leads (sternal and biaxillary) to monitor HR. Cardiac function was estimated via impedance cardiography using the Renaissance Technology, Inc. IQ System 101 Impedance Cardiograph (Newtown, Pennsylvania) with four "band-spot" electrodes placed laterally on the neck and lower torso. BP was recorded using a Finapres finger cuff device (Ohmeda Model 2300, Louisville, Colorado). Estimates of head level BP were obtained by positioning the hand at shoulder level with the arm supported in a custom designed sling. The distance between the finger cuff and ectocanthus was also recorded before and after each centrifuge insertion.

11. Subjects determined and verbally reported how their visual field was affected by monitoring light emitting diodes (LED's) placed in the centrifuge gondola at 15 deg increments from a central LED situated directly in front of the ejection seat head box. The visual endpoint was defined as complete loss of peripheral vision (as subjectively measured by a reduction of peripheral vision (peripheral light loss (PLL)) to a 60 deg cone using fixed reference lights) or greater than 75% overall loss of vision. Since operational helicopter crews are not instructed in the performance of anti-G straining maneuvers, subjects were instructed to remain relaxed throughout the insertion. However, since the natural response to acceleration stress is to tighten the muscles and this experiment was intended to determine the effects of varying G-loads during an actual mission, rather than stopping the run due to reaching visual endpoint, subjects were instructed to tense their muscles and/or grunt to "clear their lights." Subjective fatigue and nausea estimates were made throughout the insertion by subjects using a modified Borg scale (reference 10) (see table 3).

Table 3
MODIFIED BORG SCALE FOR SUBJECTIVE FATIGUE ESTIMATION

Subjective Fatigue and Nausea Scale	
Index	Verbal Descriptor
1	Nothing
2	Noticeable
3	Light
4	Weak
5	Moderate
6	Somewhat
7	Strong
8	Hard
9	Heavy
10	Maximal

METHOD

PUSH-PULL MISSION

12. The centrifuge was programmed in the open loop mode (subject not in control of the acceleration profile) to simulate the transitions from -Gz to +Gz-loads (including levels, durations, and onset/offset rates) currently experienced in high performance helicopter mission scenarios. During the first 25 min of each centrifuge insertion, the G-loads and onset/offset rates simulated the capabilities of aircraft now flying in the U.S. Navy fleet (range: -0.2 to +3.5 Gz). This period was referred to as the current mode (CM). Following 5 min rest, the maneuver sequence was repeated with the G-loads scaled to represent the capabilities of future, more aggressive, rotary wing aircraft (range: -1.0 to +4.5 Gz). This phase was called the future mode (FM). Note that during this phase the onset/offset rates were similar to the CM. Overall, the insertion lasted 60 min. Two repetitions of the push-pull mission (PPM) were conducted on separate days. To minimize the effects of motion sickness during push-pull transitions in the centrifuge, the gondola was tilted back such that a constant +1.5 Gx was applied, a technique used successfully in previous push-pull studies (reference 11). The G-levels, onset/offset rates, and durations of the profiles were based on actual recordings of rotary wing maneuvers taken from Apache, Black Hawk, and BK-117 aircraft. These maneuvers are shown in figures 1 through 9.

13. Gradual Onset Run (GOR) (figure 1) is a purely +Gz (pull) maneuver based on an Apache profile. The profile begins at +1 Gz and rises at 0.1 g/sec to a +2.5 Gz 5 sec plateau. The offset rate from that plateau was 0.2 g/sec. The FM GOR features the same onset and offset rate but with a 5 sec +4.5 Gz plateau. (Overall duration: CM: 34 sec, FM: 63 sec.)

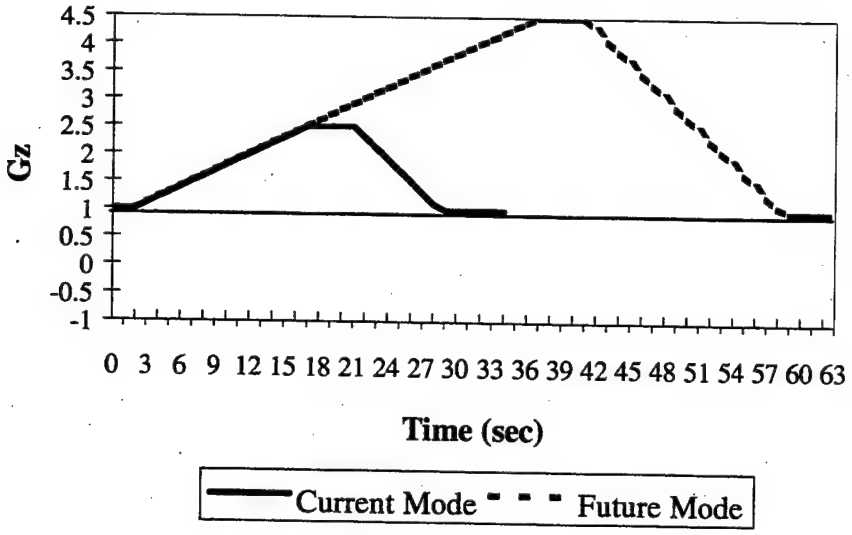

Figure 1
GOR

14. Rapid Onset Run (ROR) (figure 2) is a push-pull maneuver based on an Apache profile. From +1 Gz, there is a push at 0.1 g/sec to a +0.6 Gz 6 sec plateau, followed by a 1.0 g/sec rise to +1.0 Gz. Then there is a pull at 1.25 g/sec to a +3.5 Gz 2 sec plateau followed by a 0.56 g/sec offset rate. In the FM ROR, the pull phase peaks at +4.5 Gz 2 sec plateau. (Overall duration: CM and FM: 30 sec.)

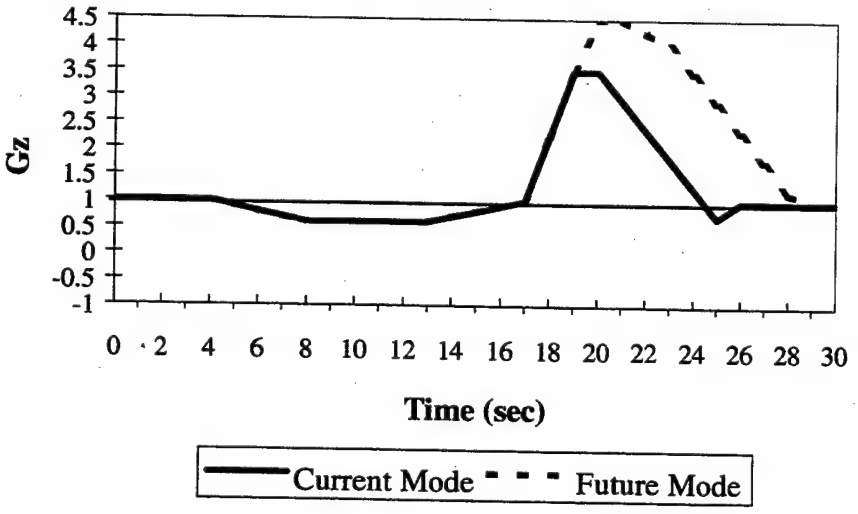

Figure 2
ROR

15. Pushover (PO) (figure 3) was based on a complicated pull, push, pull, push, pull BK-117 profile. The sequence is as follows: starting from a +1 Gz, pull #1 at 0.34 g/sec to +2.0 Gz (hold for 3 sec), push #1 at -0.5 g/sec to +0.5 Gz (hold for 2 sec), pull #2 to 0.25 g/sec to +1 Gz, push #2 at -0.5 g/sec to +0.5 Gz (hold for 2 sec), pull #3 at 0.29 g/sec to +2.25 Gz (hold for 2 sec), return to +1 Gz at 0.25 g/sec. During FM, pull #1 peaks at +2.5 Gz, push #1 and #2 reaches -1 Gz, and pull #3 peaks at +3.5 Gz. (Overall duration: CM: 28 sec, FM: 39 sec.)

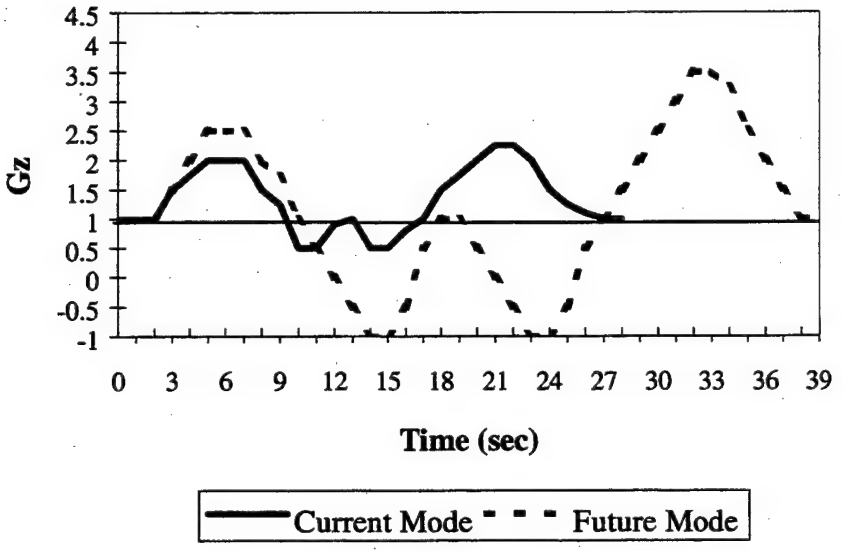

Figure 3
PO

16. "Modified" Lazy Eight (L8) (figure 4) was based on a BK-117 profile including a brief push, pull, longer push, followed by a pull with 21 sec (42 sec FM) of varying +Gz levels. From +1 Gz, there is a 1 sec push (#1) to +0.8 Gz, a 1 sec rise to +1 Gz, then a 0.25 g/sec pull (#1) to +1.5 Gz (hold for 2 sec), begin a push (#2) at 0.1 g/sec to +1.2 Gz (hold for 3 sec), then accelerate the push (#3) at 0.2 g/sec to +0.5 Gz (hold for 3 sec), 1 sec pull (#2) to +2 Gz (hold for 2 sec), followed by a variety of +Gz levels, peaking at +2.5 Gz. In the FM version, push #1 falls to +0.5 Gz, pull #1 peaks at +2.0 Gz, push #2 to +1.4 Gz, push #3 falls to -1 Gz, pull #3 to +3.5 Gz, with a peak of +4.5 Gz during the extended +Gz phase. (Overall duration: CM: 50 sec, FM: 68 sec.)

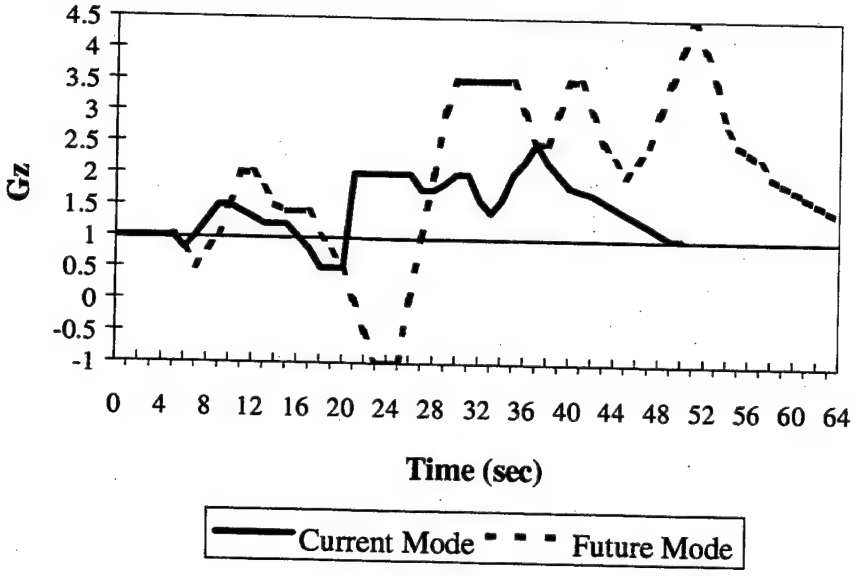

Figure 4
MODIFIED L8

17. Low/High Rapid Maneuver (LHR) (figure 5) is a pull, push, pull maneuver based on a Black Hawk profile. From +1 Gz, pull #1 rises at 0.18 g/sec to a +1.9 Gz 2 sec plateau, then pushes at 0.34 g/sec to -0.1 Gz (hold for 2 sec), pull #2 at 0.62 g/sec to +3.0 Gz (hold for 2 sec), fall at 0.5 g/sec to +2.0 Gz, then returning to +1.0 Gz at 0.15 g/sec. FM LHR pull #1 reaches +3.0 Gz, pushes down to -1.0 Gz, pull #2 peaks at +4.5 Gz, and falls to +3.5 Gz prior to ending at +1.0 Gz. (Overall duration: CM: 35 sec, FM: 61 sec.)

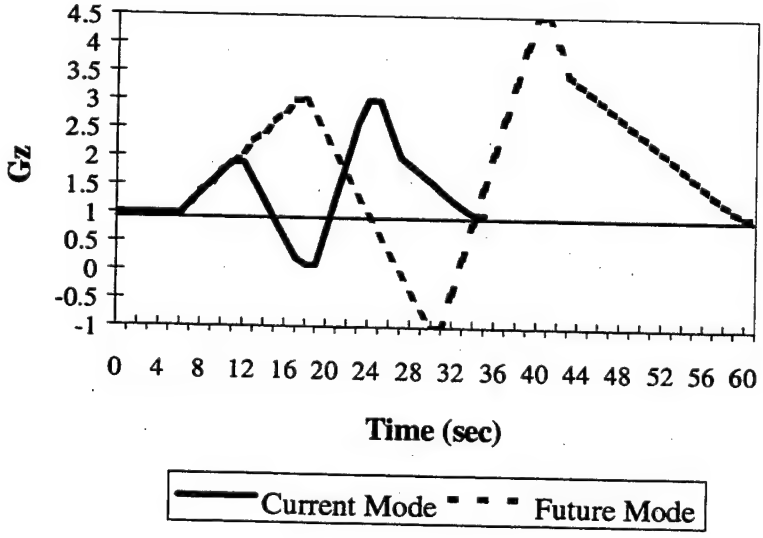

Figure 5
LHR MANEUVER

18. Low/High Gradual Maneuver (LHG) (figure 6) is an Apache-based profile featuring another pull, push, pull maneuver. Starting from +1 Gz, pull #1 rises at 0.1 g/sec to a +1.4 Gz 5 sec plateau, then pushes at 0.19 g/sec to +0.26 Gz (hold for 3 sec), pull #2 at 0.17 g/sec to +2.81 Gz (hold for 6 sec), then returning to +1.0 Gz at 0.25 g/sec. In FM LHG, pull #1 goes to +2.0 Gz, the push to -1 Gz, and pull #2 reaches +4.5 Gz. (Overall duration: CM: 52 sec, FM: 93 sec.)

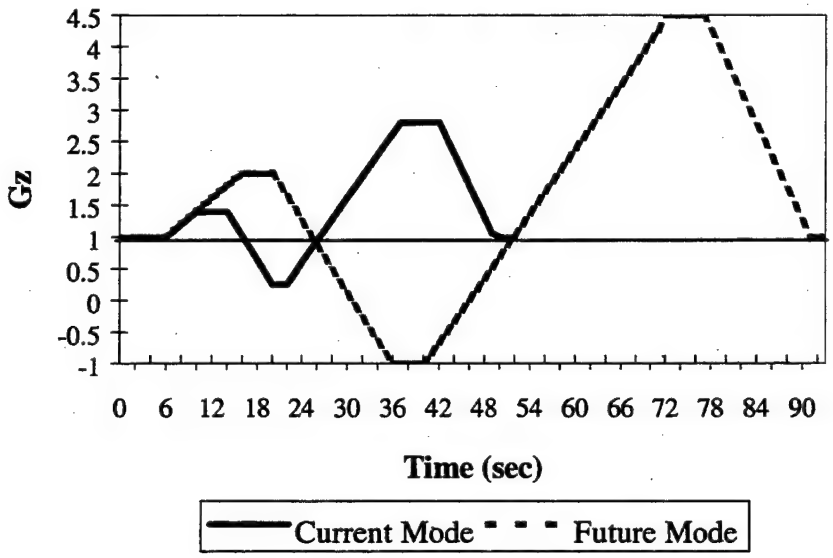

Figure 6
LHG MANEUVER

19. Ridgeline Crossing (RLC) (figure 7) is a pull, push, pull sequence based on a BK-117 profile derived from low level terrain following maneuvers. From +1.0 Gz, pull #1 rises at 0.5 g/sec to a +1.5 Gz 2 sec plateau, push at 0.43 g/sec to -0.2 Gz, pull #2 at 0.65 g/sec to +1.75 Gz, then returning to +1.0 Gz at 0.25 g/sec (with a 2 sec pause at +1.5 Gz). The FM RLC features a +2.0 Gz pull #1, -1.0 Gz push, and +2.5 Gz pull, with a 2 sec pause at +2.0 Gz during the offset to +1.0 Gz. Since RLC was a relatively short profile, it was repeated twice with an 18 sec rest at +1 Gz between repetitions. (Overall duration: CM: 48 sec, FM: 66 sec.)

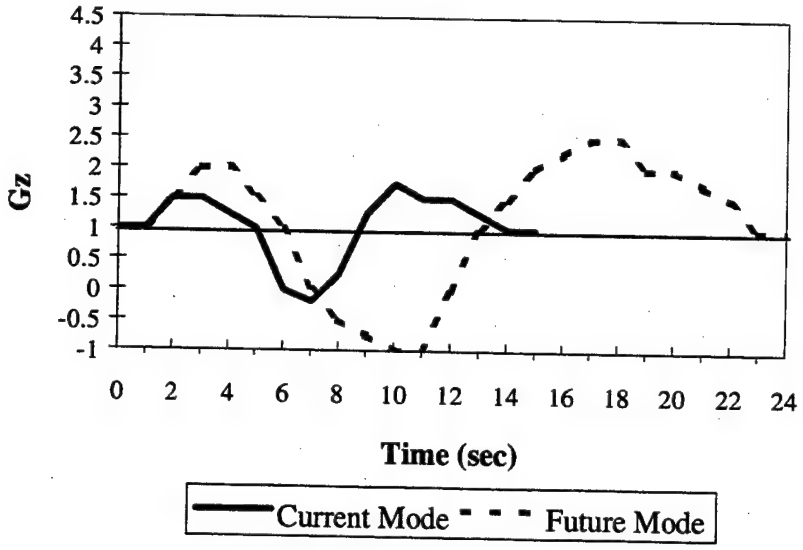

Figure 7
RLC

20. Loop (figure 8), also based on a BK-117 profile, is very similar to RLC. From +1.0 Gz, pull #1 rises at 0.2 g/sec to +2.0 Gz, push at 0.3 g/sec to +0.5 Gz, pull #2 at 0.67 g/sec to a +2.5 Gz 2 sec plateau, then offset at 0.5 g/sec to +1.5 Gz (hold for 2 sec), then returning to +1.0 Gz at 0.25 g/sec. During the FM version, pull #1 rises to +2.75 Gz, push at 0.46 g/sec to -0.5 Gz, pull #2 at 0.86 g/sec to a +3.5 Gz 2 sec plateau, then offset at 0.5 g/sec to +2.5 Gz (hold for 2 sec), then returning to +1.0 Gz at 0.5 g/sec. Loop was also repeated twice with a 32 sec period at +1 Gz between repetitions. (Overall duration: CM: 80 sec, FM: 92 sec.)

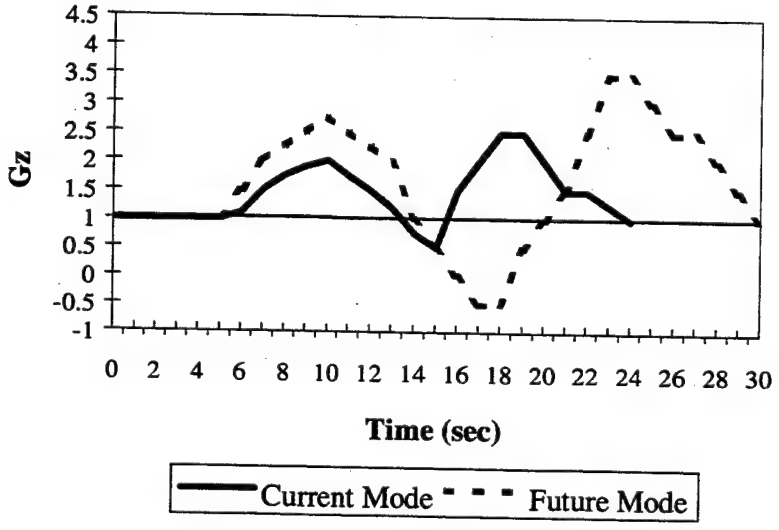

Figure 8
LOOP

21. Hammerhead (HH) (figure 9), based on a BK-117 profile, was the last of the pull-push-pull maneuvers. It has a variety of intermediate steps, but peaks at pull #1 at +1.75 Gz, push at +0.25 Gz, and pull #2 at +2.25 Gz. FM HH peaks at pull #1 at +2.0 Gz, push at -1.0 Gz, and pull #2 at +3.25 Gz. HH was also repeated twice with a 32 sec period at +1 Gz between maneuvers. (Overall duration: CM: 80 sec; FM: 84 sec.) For both CM and FM, the sequence of maneuvers during an insertion was GOR1, ROR1, PO, L8, LHR, ROR2, LHG, ROR3, two RLC's, two Loops, two HH's, and GOR2 maneuvers. The GOR and ROR maneuvers were repeated to determine if the physiological response to these profiles changed as the length of the insertion increased, thereby providing an index of the effects of cumulative G-stress.

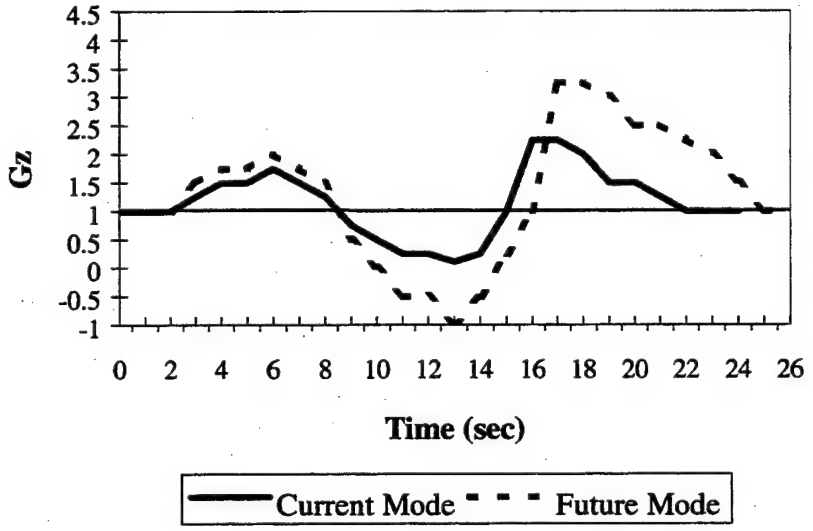

Figure 9
HH

+Gz MISSION

22. In this phase, subjects experienced the same mission scenario outlined in the PPM except that all transitions < +1.0 Gz were fixed at +1.0 Gz for both CM and FM. The +Gx bias, timing, and onset/offset rate transitions were identical; only the G-loads < +1.0 Gz differed. As an example, figure 10 shows the CM +Gz mission (GM) maneuver sequence. Two repetitions of GM were conducted on separate days. The order that the missions were run were randomized to avoid any learning effects. Therefore, subjects participated in two PPM's and two GM insertions during 1 week.

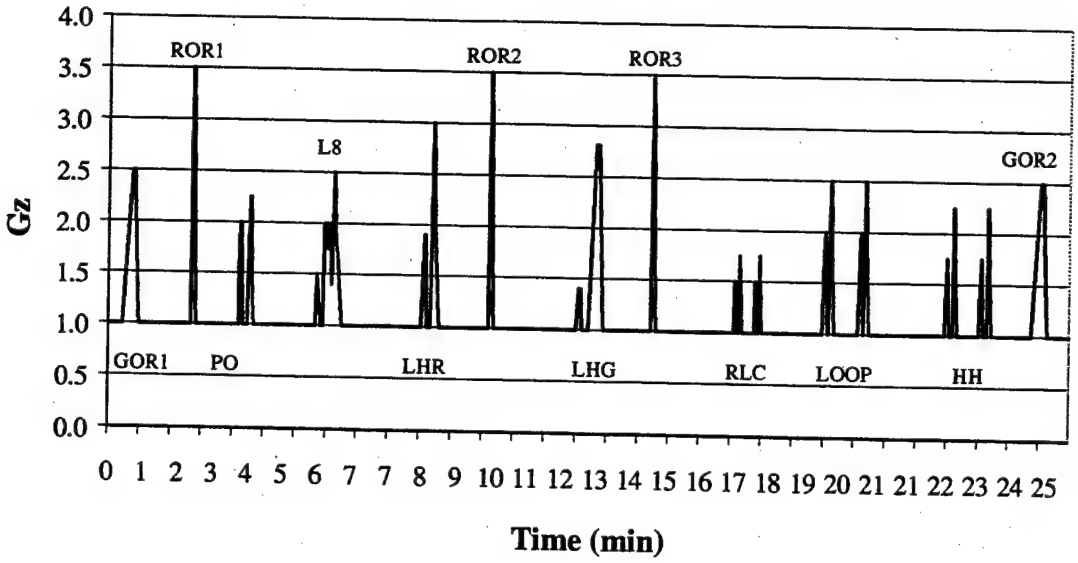

Figure 10
CM GM SEQUENCE

DATA ANALYSIS

PERIPHERAL LIGHT LOSS

23. Light loss was determined based on a subject's ability to see LED lights arranged in the gondola at 15 deg increments describing a 90 deg arc on either side of center. Light loss was reported by subjects as an inability to see some of the LED's and/or a percentage of overall dimming. These values were averaged for each type of mission and differences between the type of mission, type of maneuver and gender were determined by repeated measures ANOVA (α = 0.05) and source of those differences assessed with a post hoc Fisher's Least Squares Difference (LSD) Multiple-Comparison test (Number Cruncher Statistical Systems 97, JL Hintze, Kaysville, Utah).

24. There was no light loss during the CM scenarios for both GM and PPM, except during the ROR's. Peak PLL was reported during the third ROR with three subjects at 30 deg or 40% overall gray and three others at 10 to 20%. Subjects reported that light loss occurred during the transition less than +1 Gz to greater than +1 Gz during PPM. No subjects required muscle tensing during these runs and all runs were completed.

25. Loss of visual field during the FM scenarios was significant. There were no significant differences in PLL between the first and second PPM's or between the two GM's (i.e., no learning effects). Therefore, statistics were performed on the mean reported light loss (see table 4). Repeated measures ANOVA (using subject as a random variable and degrees of light loss, mission (PPM or GM), and type of maneuver as fixed variables) indicated that overall the light loss during PPM was statistically significantly greater than during GM ($F = 5.94$, $p = 0.041$). There was also an interaction between type of mission and maneuver ($F = 3.51$, $p = 0.002$). To clarify the source of these differences, additional ANOVA focussing on the individual maneuvers indicated no difference in light loss during the GOR relative to type of mission or whether it was the first or second GOR. There was also no statistically significant difference during both the LHR and LHG maneuvers. While mean light loss increased during each succeeding PPM ROR maneuver, the increases were not statistically significant. Light loss was significantly greater during the PPM PO and L8 as compared to the GM ($F = 12.66$, $p = 0.007$ and $F = 8.89$, $p = 0.018$, respectively).

Table 4
PLL DURING FM

Mean ± standard deviation and maximum reported PLL (deg) during FM PPM and GM.

PLL during FM Maneuvers				
Maneuver	Mean PLL (PPM)	Mean PLL (GM)	Max PLL (PPM)	Max PLL (GM)
GOR1	26 ± 17	22 ± 26	53	68
ROR1	41 ± 27	34 ± 28	70	73
PO	14 ± 17	0 ± 0	45	0
L8	40 ± 33	12 ± 16	85	38
LHR	56 ± 35	42 ± 31	83	75
ROR2	48 ± 31	48 ± 29	78	75
LHG	43 ± 37	37 ± 33	85	83
ROR3	50 ± 31	42 ± 29	90	75
RLC	1 ± 2	0 ± 0	5	0
Loop	1 ± 2	0 ± 0	5	0
HH	2 ± 7	1 ± 2	20	5
GOR2	19 ± 26	26 ± 30	75	83

26. Subjects did use muscle tensing or employ breathing patterns to help maintain their vision during FM GOR, ROR, LHR, and LHG maneuvers. The amount of muscular straining or tensing varied between individuals, with the ROR, LHR, and LHG maneuvers requiring the most effort. The two female subjects, N4 and N5, often used a breathing technique similar to a Lamaze pattern, i.e., short exhaled puffs, which worked well. Repeated measures ANOVA (using subject as a random variable and level of effort as a fixed variable) indicated that the level of effort during PPM was slightly, though not significantly, greater than during GM ($F = 3.60$, $p = 0.094$).

FATIGUE AND NAUSEA

27. Subjects reported subjective fatigue and nausea after each run using the scale in table 3. There were no significant differences in fatigue or nausea between the first and second PPM's or between the two GM's (i.e., no learning effects). Means scores for each subject for each mission and mode were calculated (see table 5) and compared using the Wilcoxon Signed-Rank Test for Difference in Medians. While it was shown that subjective fatigue and nausea ratings were statistically significantly greater during FM versus CM (PPM: Z value = 3.86, $p < 0.001$; GM: Z value = 6.08, $p < 0.001$), as well as fatigue during current PPM versus GM (Z value = 4.39, $p < 0.001$), the ratings indicated that subjects were not very fatigued or nauseous.

Table 5
SUBJECTIVE FATIGUE AND NAUSEA RATINGS

Mean ± standard deviation subjective fatigue and nausea ratings during CM and FM PPM and GM.

Subjective Fatigue and Nausea Ratings				
Maneuver	PPM Fatigue	GM Fatigue	PPM Nausea	GM Nausea
CM				
GOR1	1.2 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.3
ROR1	1.2 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.3
PO	1.1 ± 0.3	1.0 ± 0.0	1.1 ± 0.2	1.1 ± 0.3
L8	1.2 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.3
LHR	1.3 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.3
ROR2	1.3 ± 0.7	1.0 ± 0.0	1.0 ± 0.0	1.1 ± 0.3
LHG	1.5 ± 1.1	1.0 ± 0.0	1.1 ± 0.2	1.1 ± 0.3
ROR3	1.3 ± 0.7	1.0 ± 0.2	1.1 ± 0.2	1.1 ± 0.3
RLC	1.1 ± 0.2	1.1 ± 0.2	1.1 ± 0.3	1.1 ± 0.3
Loop	1.3 ± 0.5	1.1 ± 0.3	1.1 ± 0.3	1.1 ± 0.3
HH	1.3 ± 0.6	1.1 ± 0.3	1.1 ± 0.2	1.1 ± 0.3
GOR2	1.4 ± 0.8	1.1 ± 0.3	1.1 ± 0.3	1.1 ± 0.3
FM				
GOR1	1.2 ± 0.4	1.2 ± 0.5	1.0 ± 0.0	1.1 ± 0.3
ROR1	1.2 ± 0.4	1.2 ± 0.5	1.0 ± 0.0	1.1 ± 0.3
PO	1.2 ± 0.7	1.2 ± 0.5	1.0 ± 0.0	1.1 ± 0.3
L8	1.2 ± 0.5	1.4 ± 0.7	1.1 ± 0.2	1.1 ± 0.3
LHR	1.4 ± 0.5	1.4 ± 0.7	1.0 ± 0.0	1.1 ± 0.3
ROR2	1.4 ± 0.5	1.3 ± 0.7	1.0 ± 0.0	1.1 ± 0.3
LHG	1.5 ± 0.7	1.6 ± 0.9	1.1 ± 0.2	1.2 ± 0.5
ROR3	1.6 ± 0.7	1.5 ± 0.8	1.0 ± 0.0	1.2 ± 0.5
RLC	1.6 ± 0.7	1.6 ± 0.9	1.2 ± 0.4	1.2 ± 0.5
Loop	1.6 ± 0.8	1.6 ± 1.0	1.0 ± 0.0	1.3 ± 0.7
HH	1.7 ± 0.9	1.6 ± 1.2	1.2 ± 0.4	1.3 ± 0.7
GOR2	1.7 ± 1.0	1.7 ± 1.1	1.1 ± 0.2	1.3 ± 0.6

BLOOD PRESSURE

28. Since there was minimal PLL during RLC, Loop, and HH, cardiovascular data analysis was focussed on all the other maneuvers. In order to analyze the BP data, two preprocessing steps were required. First, it was necessary to remove the baseline shifts which were an artifact induced in the Finapres when the centrifuge gondola rotated during the maneuvers. This was done by passing the digitized waveform through a 6^{th} order high pass Butterworth filter. Second, since this

step centered the waveform about the origin (i.e., an AC filter), it was necessary to add a DC offset to the filtered waveform to retain the relative BP magnitude. The offset was derived by calculating the 10 sec average of resting BP values measured immediately prior to the maneuver (a period without baseline artifacts). This was done for each individual BP recording during each maneuver. Since HR, and therefore beat-by-beat SBP change, varied within and between subjects for a given maneuver (with each data point occurring anywhere from 0.36 to 0.82 sec), BP data were first aligned according to the acceleration profiles. For example, each maneuver was represented by a series of fiducial points in the G profile, such as the beginning of a push transition, the start and end of a plateau, etc. BP data for each subject would then be organized relative to those points in order to compare the responses to a given maneuver for each PPM and GM exposure. In cases in which HR during a given set of fiducial points was faster than another (hence more BP points), for example in the ROR pull phase during PPM versus GM, pairs of consecutive BP values were averaged (thereby reducing the number of BP points). In this fashion, BP responses at the same G level and point during a given maneuver could be compared between PPM and GM within and between subjects. Once aligned, mean PPM and GM values for each maneuver for each insertion were determined for each subject. To normalize the data, the relative ΔSBP was determined for each maneuver based on the differences between the BP response at G and a 10 sec average calculated during the rest phase immediately prior to that maneuver. Repeated measures ANOVA were conducted to determine if there were significant differences in ΔSBP based on mission (PPM versus GM), on mode (CM versus FM), and in the case of ROR and GOR, on succeeding repetitions of the same profiles. Sources of differences were determined using the Fisher's LSD test. In order to set up the repeated measures ANOVA, a factor was used to segment each portion of the maneuver, thereby providing a means to determine differences in response based on different G transitions (push or pull) within a given maneuver. For example, a CM ROR was segmented into 24 points based on the push phase (including 3 points during the transition from +1 to +0.6 Gz, 4 points during the +0.6 Gz plateau, and 3 points during the return to +1 Gz), the pull phase (including 4 points during the rise to +3.5 Gz plateau and the peak value at plateau), the offset to +1 Gz (6 points between +3.5 and +1 Gz), and during 10 sec of recovery (4 points at +1 Gz). In this manner, responses during CM ROR could be tested for differences in ΔSBP approximately every second.

29. In general, when subjects were exposed to < +1 Gz, SBP rose and when they were exposed to > +1 Gz, SBP fell. Summary mean ΔSBP data for all subjects during CM simulations are found in tables A-1 through A-6. Tables A-7 through A-12 contain results during the FM simulations.

CURRENT MODE RAPID ONSET RUN CHANGE IN SYSTOLIC BLOOD PRESSURE

30. The drop in ΔSBP during the pull phase of the ROR tended to increase with each succeeding repetition of the ROR. Subject pool mean peak changes during PPM were -8.1, -11.0, and -12.8 mmHg (ROR1, ROR2, ROR3, respectively) and -3.9, -6.6, and -7.8 mmHg (ROR1, ROR2, ROR3, respectively) during GM. The rate of decrease in ΔSBP during this period was greater during PPM (-2.4, -3.5, and -4.4 mmHg/sec (ROR1, ROR2, ROR3, respectively)) as compared to GM (-1.3, -1.7, -2.1 mmHg/sec (ROR1, ROR2, ROR3, respectively)). During the offset from the +3.5 Gz peak, ΔSBP gradually rose to a greater than prerun level, demonstrating

the hyperemic response typical of exposures to +Gz stress. The rate of increase during PPM was slightly faster (+1.5, +1.6, and +1.4 mmHg/sec (ROR1, ROR2, ROR3, respectively)) than GM (+0.8, +1.1, and +1.0 mmHg/sec (ROR1, ROR2, ROR3, respectively)). ANOVA results indicated that there was a significant difference in the ΔSBP between PPM and GM ($F = 2.58$, $p < 0.001$) and overall between the first and the next two repetitions of the ROR ($F = 22.82$, $p < 0.001$). Figure 11 shows the difference between PPM and GM ROR1 and ROR3.

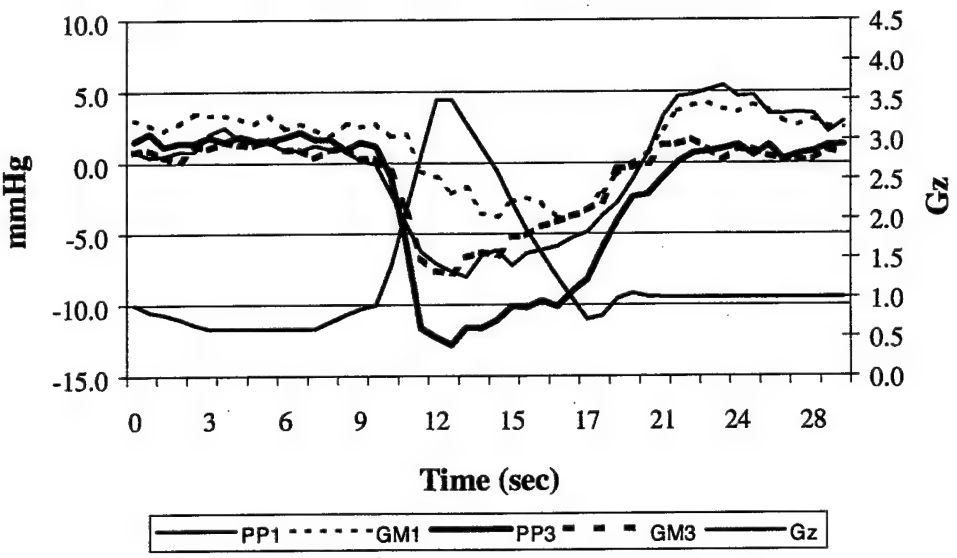

Figure 11
ΔSBP DURING CM ROR

FUTURE MODE RAPID ONSET RUN CHANGE IN SYSTOLIC BLOOD PRESSURE

31. The drop in ΔSBP during the pull phase of the ROR was greatest during ROR1 as compared to the succeeding ROR's. Subject pool mean peak changes during PPM were -26.2, -21.5, and -22.9 mmHg (ROR1, ROR2, ROR3, respectively) and -19.5, -23.8, and -19.7 mmHg (ROR1, ROR2, ROR3, respectively) during GM. The rate of decrease in ΔSBP during this period was greater during PPM ROR1 and ROR3 (-5.3, -4.2, and -4.8 mmHg/sec (ROR1, ROR2, ROR3, respectively)) as compared to GM (-3.5, -4.4, -4.4 mmHg/sec (ROR1, ROR2, ROR3, respectively)). During the offset from the +4.5 Gz peak, ΔSBP gradually rose to a level greater than prerun. The rate of increase during PPM was similar to (+2.7, +2.5, and +2.7 mmHg/sec (ROR1, ROR2, ROR3, respectively)) GM (+2.9, +2.4, and +2.4 mmHg/sec (ROR1, ROR2, ROR3, respectively)). ANOVA results indicated that there was a significant difference in the ΔSBP between PPM and GM ($F = 3.43$, $p < 0.001$), based on the fact that ΔSBP dropped more quickly and to a greater extent during the ROR pull phase of PPM and overall between the first and the next two repetitions of the ROR ($F = 6.39$, $p = 0.002$). Figure 12 shows the difference between PPM and GM ROR1 and ROR3. The green line indicates -22 mmHg which, according to the hydrostatic column theory of G tolerance, corresponds to a 1 g drop in acceleration tolerance (reference 12).

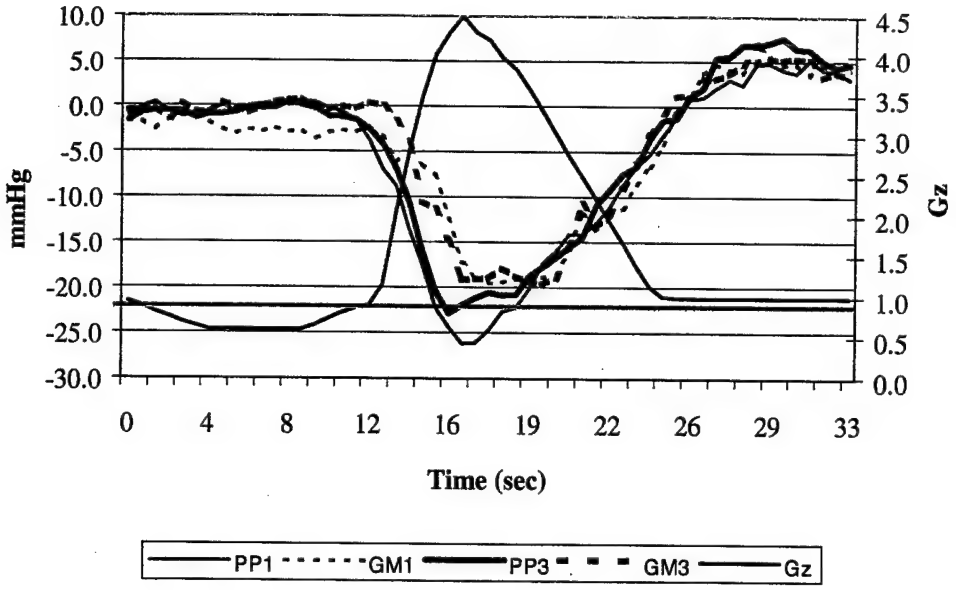

Figure 12
ΔSBP DURING FM ROR

CURRENT MODE GRADUAL ONSET RUN CHANGE IN SYSTOLIC BLOOD PRESSURE

32. The purpose of including the two purely +Gz GOR's bracketing the other maneuvers was to determine if the cardiovascular response was different at the end of the mission segment due to fatigue and if there was a difference after exposure to the intervening series of PPM as compared to the GM maneuvers. For both mission modes, the drop in ΔSBP was greater during the second GOR as compared to the first. However, ANOVA and Fisher's LSD results indicated that the drop was statistically greater only during GM ($F = 5.91$, $p = 0.015$). Despite this statistical result, the actual changes were low (peak decreases for the subject pool: 4.4 mmHg (PPM); 5.6 mmHg (GM)). Of interest was the increased rate of change in ΔSBP during the slow rise in +Gz-load during the second GOR (PPM: 0.18 versus 0.10 mmHg/sec, GOR2 and GOR1, respectively (65% faster); GM: 0.29 versus 0.23 mmHg/sec, GOR2 and GOR1, respectively (31% faster)) and it took longer to recover SBP during the +Gz-load offset during the second GOR (PPM: 0.31 versus 0.54 mmHg/sec, GOR2 and GOR1, respectively (43% slower); GM: 0.36 versus 0.40 mmHg/sec, GOR2 and GOR1, respectively (10% slower)). There were no statistical differences demonstrated when comparing PPM versus GM ΔSBP.

FUTURE MODE GRADUAL ONSET RUN CHANGE IN SYSTOLIC BLOOD PRESSURE

33. In a similar fashion to the CM GOR, the drop in ΔSBP was greater during the second GOR as compared to the first for both PPM and GM ($F = 112.72$, $p < 0.001$). Furthermore, ANOVA and Fisher's LSD results indicated that the decrease in ΔSBP during the second GM was statistically greater than during PPM ($F = 18.04$, $p < 0.001$). The peak decrease in ΔSBP during GM was -12.2 and -16.0 mmHg (GOR1 and GOR2, respectively) and during PPM it was -10.9 and -14.1 mmHg (GOR1 and GOR2, respectively). The rate of decrease during the +Gz onset was greater during GOR2 for both modes (PPM: 0.35 versus 0.25 mmHg/sec, GOR2 and GOR1, respectively (40% faster); GM: 0.42 versus 0.39 mmHg/sec, GOR2 and GOR1, respectively (8% faster)). During the offset, the increase in SBP towards recovery was faster during PPM GOR2 (GOR2: 0.65 mmHg, GOR1: 0.54 mmHg; 21% faster) while the increase was slower during GM (GOR2: 0.77 mmHg, GOR1: 0.94 mmHg; 18% slower). These differences between mode and first and second GOR are shown graphically in figure 13.

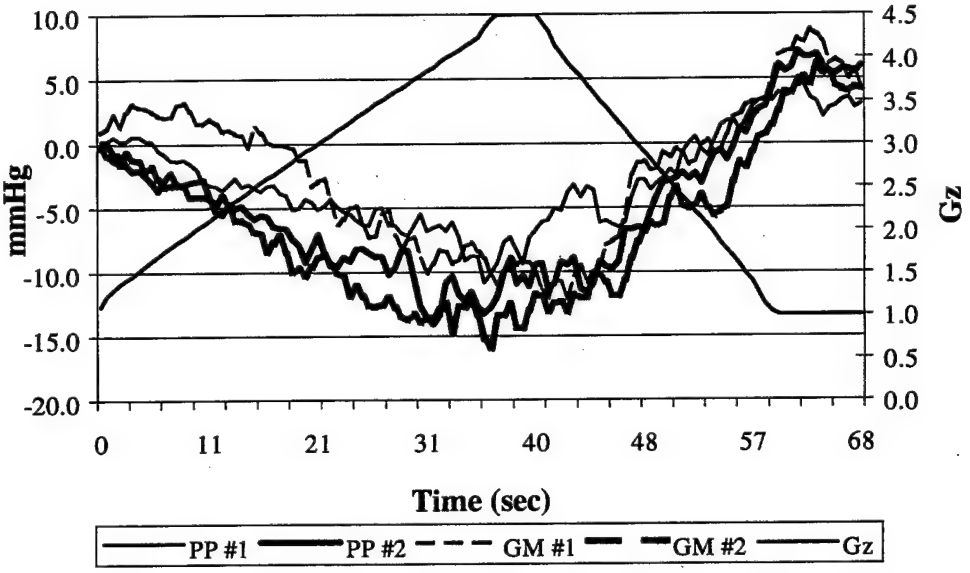

Figure 13
ΔSBP DURING FM GOR

CURRENT MODE LOW/HIGH RAPID MANEUVER CHANGE IN SYSTOLIC BLOOD PRESSURE

34. In the low/high maneuvers, the effect of transition rate during a pull-push-pull maneuver could be assessed. During the first pull SBP falls, with the push SBP rapidly rises, and with the second pull SBP falls, only to rise again with the offset from the second peak. Overall, ANOVA failed to demonstrate any significant differences based on type of mission. For example, the peak decrease in ΔSBP was 7.3 mmHg for both PPM and GM. The cardiovascular system quickly responded to these changes in applied acceleration stress, particularly during PPM. During the push, the rate of increase in ΔSBP was the same for PPM and GM (0.72 mmHg/sec). But

following this push, ΔSBP dropped 34% faster during PPM (2.23 mmHg/sec) versus GM (1.47 mmHg/sec). During the offset after the second pull, the rate of recovery was 72% slower during PPM (0.48 mmHg) than during GM (0.82 mmHg).

FUTURE MODE LOW/HIGH RAPID MANEUVER CHANGE IN SYSTOLIC BLOOD PRESSURE

35. When the low/high rapid maneuver was scaled for more aggressive platforms, both the timing of the cardiovascular response and the statistical results were the same: no significant differences in ΔSBP based on type of mission. The peak decrease in ΔSBP was comparable between both missions (PPM: -18.3 mmHg; GM: -21.4 mmHg), though the hyperemic response during recovery of SBP was greater during PPM versus GM (PPM: 10.4 mmHg; GM: 4.4 mmHg). Unlike the CM, the rate of decrease in ΔSBP during the push was higher during GM versus PPM (PPM: 1.1 mmHg/sec; GM: 1.6 mmHg/sec (45% faster)), as well as during the second pull (PPM: 1.7 mmHg/sec; GM: 2.0 mmHg/sec (14% faster)), and the rate of recovery was 9% quicker during PPM versus GM (PPM: 1.3 mmHg/sec; GM: 1.2 mmHg/sec).

CURRENT MODE LOW/HIGH GRADUAL MANEUVER CHANGE IN SYSTOLIC BLOOD PRESSURE

36. In this pull-push-pull maneuver, the effect of slower transition rates was investigated. As in the LHR maneuver, ΔSBP followed the change in Gz with increased SBP as Gz stress lessened and decreased with higher +Gz. No statistical differences between PPM and GM ΔSBP were found. The maximum decline in ΔSBP was similar for both missions (PPM: -8.8 mmHg; GM: -9.8 mmHg). The rate of change during the second pull was the same between missions (PPM: 0.65 mmHg/sec; GM: 0.64 mmHg/sec) and the PPM rate of recovery was only 7% faster (PPM: 0.90 mmHg/sec; GM: 0.83 mmHg/sec).

FUTURE MODE LOW/HIGH GRADUAL MANEUVER CHANGE IN SYSTOLIC BLOOD PRESSURE

37. While the overall decline in ΔSBP was greater during PPM, no statistical differences between PPM and GM ΔSBP were found. The maximum decline in ΔSBP was similar for both missions (PPM: -15.3 mmHg; GM: -14.7 mmHg). The rate of change during the second pull was 23% faster during PPM (PPM: 0.32 mmHg/sec; GM: 0.25 mmHg/sec) and the PPM rate of recovery was 12% faster (PPM: 0.96 mmHg/sec; GM: 0.85 mmHg/sec).

CURRENT MODE PUSHOVER CHANGE IN SYSTOLIC BLOOD PRESSURE

38. As with the other pull-push-pull type maneuvers, ΔSBP followed the general changes in Gz-stress, with a slightly greater overall decline in ΔSBP during PPM. There was no apparent effect of the modest pull between the two pushes in mean subject pool ΔSBP. No statistical differences between PPM and GM ΔSBP were found. The maximum decline in ΔSBP was slight for both missions (PPM: 4.2 mmHg; GM: 2.8 mmHg). The rate that ΔSBP fell during the first

pull was 75% faster during PPM (PPM: 1.04 mmHg/sec; GM: 0.26 mmHg/sec) and rise during the push was 12% slower during PPM (PPM: 0.82 mmHg/sec; GM: 0.92 mmHg/sec) than GM. During the second pull, the fall in ΔSBP continued to be greater (54%) during PPM than GM (PPM: 0.78 mmHg/sec; GM: 0.36 mmHg/sec), while the rate of recovery of ΔSBP after the offset of the second pull was greater during PPM than GM (PPM: 0.77 mmHg/sec; GM: 0.50 mmHg/sec).

FUTURE MODE PUSHOVER CHANGE IN SYSTOLIC BLOOD PRESSURE

39. ANOVA results indicated that the drop in ΔSBP was made statistically significant during PPM than GM ΔSBP ($F = 1.62$, $p = 0.023$). Fisher's LSD test determined that those differences occurred during the transition between the push and second pull phases of the maneuver and during recovery after the peak of the second push, as shown in figure 14. The maximum decline in ΔSBP was -17.0 mmHg (PPM) and -15.9 mmHg (GM). The rate that ΔSBP fell between the push and the second pull was 16% faster during PPM (PPM: 0.99 mmHg/sec; GM: 0.83 mmHg/sec), while the rate of recovery of ΔSBP after the offset of the second pull was 25% slower during PPM than GM (PPM: 1.66 mmHg/sec; GM: 2.07 mmHg/sec).

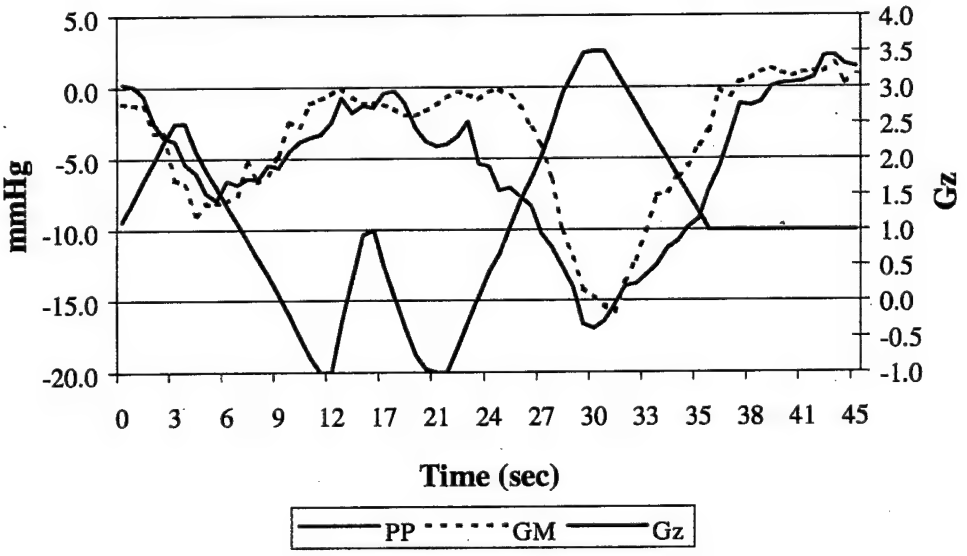

Figure 14
ΔSBP DURING FM PO

CURRENT MODE MODIFIED LAZY EIGHT CHANGE IN SYSTOLIC BLOOD PRESSURE

40. The L8 maneuver featured a low +Gz pull, followed by a push and an extended higher +Gz exposure. The overall drop in ΔSBP was slightly greater during PPM (range: $-4.9 \leq \Delta SBP \leq 0.94$ mmHg) than GM (range: $-3.6 \leq \Delta SBP \leq 2.49$ mmHg), but no statistical differences between PPM and GM ΔSBP were demonstrated.

FUTURE MODE MODIFIED LAZY EIGHT CHANGE IN SYSTOLIC BLOOD PRESSURE

41. During the more aggressive version of the L8, the overall drop in ΔSBP was slightly greater during PPM (range: $-14.9 \leq \Delta SBP \leq 3.01$ mmHg) than GM (range: $-13.1 \leq \Delta SBP \leq 4.02$ mmHg), but no statistical differences at the $p = 0.05$ level between PPM and GM ΔSBP were demonstrated. There was a marginal difference ($p = 0.52$), primarily due to the difference in fall in ΔSBP following the push phase (PPM: 2.20 mmHg/sec; GM: 1.53 mmHg/sec) and the subsequent rise in ΔSBP during the extended +Gz phase (PPM: 0.87 mmHg/sec; GM: 0.74 mmHg/sec).

HEART RATE

42. Alignment of the HR data was performed in the same fashion as the BP data. To normalize the data, the relative change in HR (ΔHR) was determined for each maneuver based on the difference between responses during Gz-stress and a 10 sec average calculated immediately before that maneuver during the rest period. Repeated measures ANOVA were conducted to determine significant differences in ΔHR based on mission (PPM versus GM), mode (CM versus FM), and successive repetitions of the same profiles. The same factor used during the BP analysis to segment the data for repeated measures ANOVA was used for ΔHR to determine differences based on the G transitions within a given maneuver. Sources of statistical differences were determined using the Fisher's LSD test. In general, HR slowed with exposure to less than 1 Gz and increased with increasing +Gz-stress. Also, ΔHR tended to be greater during PPM as compared to GM. Summary mean ΔHR data for all subjects during CM simulations are found in tables A-1 through A-6. Tables A-7 through A-12 contain results during the FM simulations.

CURRENT MODE RAPID ONSET RUN CHANGE IN HEART RATE

43. ANOVA results indicated that the overall ΔHR was slightly greater during ROR1 as compared to ROR2 and ROR3 for both PPM and GM ($F = 3.54$, $p = 0.029$). The decrease in ΔHR during the push phase was made statistically significant during PPM as compared to GM ($F = 1.78$, $p = 0.013$), though the magnitude was quite small (mean ΔHR: PPM: -2.9 ± 2.0 bpm; GM: -0.7 ± 1.7 bpm), as shown in figure 15. Subject pool mean maximum rise in ΔHR during PPM was 22.0, 20.1, and 19.8 bpm (ROR1, ROR2, ROR3, respectively) and 17.4, 18.7, and 16.5 bpm during GM (ROR1, ROR2, ROR3, respectively). The maximum changes in HR from the minimum level during the push to the maximum during the pull for PPM were 29.3, 35.3, 31.1 bpm (ROR1, ROR2, ROR3, respectively) and for GM were 31.7, 28.6, 26.5 bpm (ROR1, ROR2, ROR3, respectively). The maximum rise in HR occurred on average 4.17 ± 0.5 sec after the peak +Gz-load for both PPM and GM. The rate of increase in ΔHR during the pull phase was consistently greater during PPM as compared to GM over each repetition of ROR (mean PPM: 5.38 ± 0.19 bpm/sec; GM: 3.43 ± 0.25 bpm/sec).

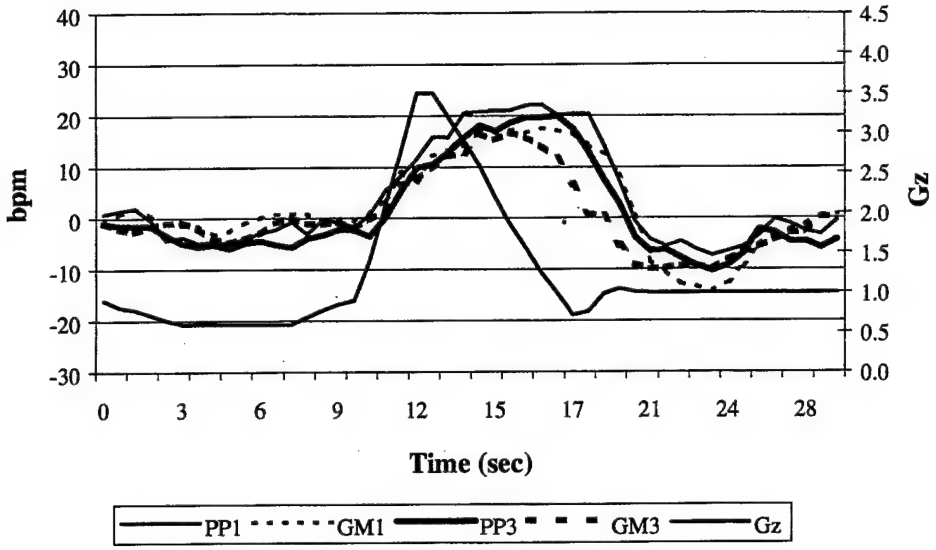

Figure 15
ΔHR DURING CM ROR

FUTURE MODE RAPID ONSET RUN CHANGE IN HEART RATE

44. ANOVA results for the more aggressive ROR's indicated that the overall increase in ΔHR was slightly less during ROR1 as compared to ROR2 and ROR3 for both PPM and GM ($F = 6.42$, $p = 0.002$). In a similar fashion to the CM results, the decrease in ΔHR during the push phase was made statistically significant during PPM as compared to GM ($F = 2.01$, $p = 0.001$), though again, the magnitude was quite small (mean ΔHR: PPM: -3.1 ± 2.9 bpm; GM: 0.5 ± 1.8 bpm). Subject pool mean maximum rise in ΔHR during PPM was 32.2, 35.4, and 34.9 bpm (ROR1, ROR2, ROR3, respectively) and 28.1, 32.4, and 28.3 bpm during GM (ROR1, ROR2, ROR3, respectively). Note, however, that when one accounts for the entire maneuver, the slightly greater overall increase in ΔHR during PPM was not significantly different from GM. The maximum rise in HR occurred after the peak of the +Gz pull at 4.2 ± 0.0 sec during PPM and after 4.6 ± 0.6 sec during GM. The rate of increase in ΔHR during the pull phase was consistently greater during PPM as compared to GM over each repetition of ROR (mean PPM: 4.17 ± 0.20 bpm/sec; GM: 3.39 ± 0.40 bpm/sec). Figure 16 details the differences between ROR1 and ROR3. Increases in ΔHR greater than 25 bpm are indicated above the green line.

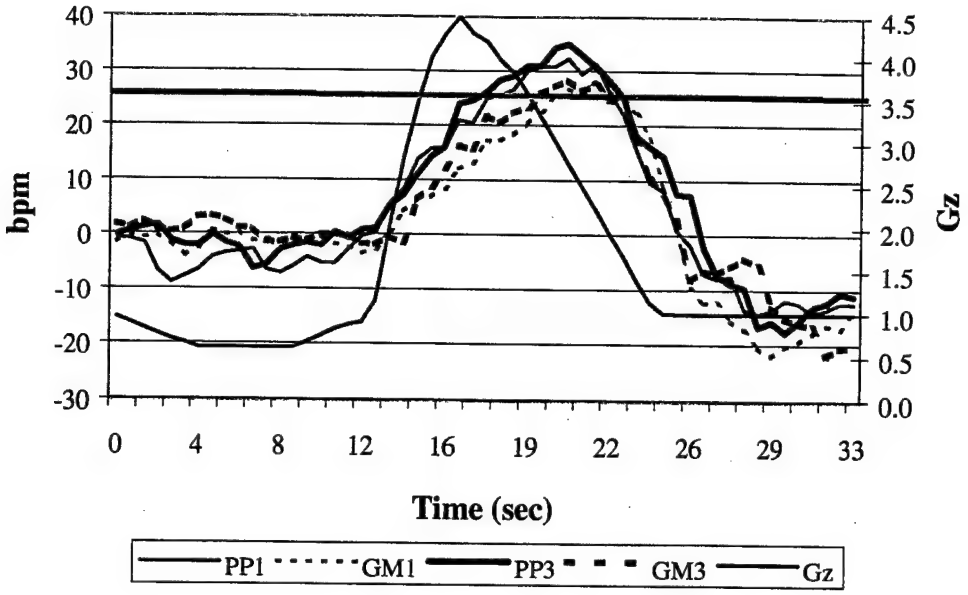

Figure 16
ΔHR DURING FM ROR

CURRENT MODE GRADUAL ONSET RUN CHANGE IN HEART RATE

45. ANOVA results indicated that there were no statistically significant difference in ΔHR between GOR1 and GOR2 regardless of whether or not there were exposures to push-pull maneuvers between them. In both PPM and GM, the maximum ΔHR attained was similar during GOR1 and GOR2 (PPM: 8.6 versus 10.9 bpm; GM: 12.4 versus 10.4 bpm, for GOR1 and GOR2, respectively). While the rate of increase in ΔHR during the rise was greater during the GOR2 versus GOR1 for PPM, the opposite was the case for GM (PPM: 0.45 versus 0.69 bpm/sec; GM: 0.88 versus 0.68 bpm/sec, for GOR1 and GOR2, respectively). Furthermore, while there was little difference in the rate of HR recovery between GOR1 and GOR2 during PPM, it took longer for HR to recover during the GOR2 during GM (PPM: -0.88 versus -0.92 bpm/sec (5% faster); GM: -1.35 versus -1.06 bpm/sec (21% slower), for GOR1 and GOR2, respectively).

FUTURE MODE GRADUAL ONSET RUN CHANGE IN HEART RATE

46. ANOVA results indicated that the increase in ΔHR between GOR1 and GOR2 was statistically significant during both PPM and GM ($F = 5.45$, $p = 0.020$). Fisher's LSD tests determined that these differences were based on HR values recorded during the maximum +Gz stress and during the offset and recovery phases of the maneuver. The maximum ΔHR attained during PPM was 26.7 (GOR1) and 37.7 bpm (GOR2) while, during GM, the peaks were 36.3 (GOR1) and 40.1 bpm (GOR2). These peak HR's occurred during the +Gz offset at 4.8 ± 0.4 sec (PPM) and 7.6 ± 0.7 sec (GM), as measured from the beginning of the maximum +Gz plateau. The rate that ΔHR increased during the rise in +Gz load was somewhat greater during GM versus

PPM, although the rate that ΔHR increased was greater for both missions during the second GOR (PPM: 0.69 versus 0.81 bpm/sec (19% faster); GM: 0.79 versus 0.96 bpm/sec (21% faster)). As in the CM, HR recovery during GOR2 was slower than GOR1 during both PPM and GM (PPM: -1.12 versus -0.86 bpm/sec (24% slower); GM: -1.84 versus -1.19 bpm/sec (35% slower), for GOR1 and GOR2, respectively). Overall, ΔHR during GM was statistically greater than during PPM ($F = 27.05$, $p < 0.001$), although the mean difference was only 2.6 ± 0.4 bpm. Figure 17 details the differences between GOR1 and GOR2. Increases in ΔHR greater than 25 bpm are indicated above the green line.

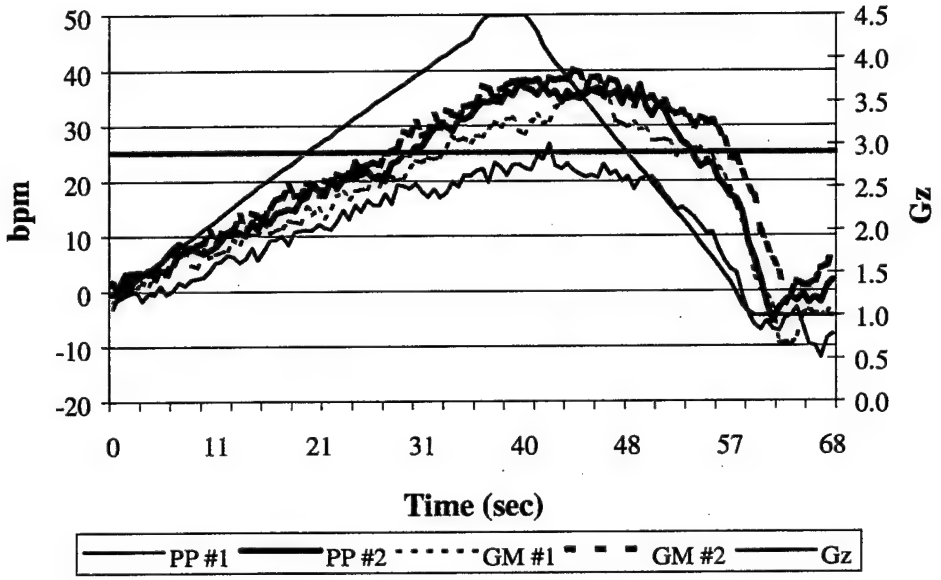

Figure 17
ΔHR DURING FM GOR

CURRENT MODE LOW/HIGH RAPID MANEUVER CHANGE IN HEART RATE

47. ANOVA results indicated that there were no statistically significant differences in ΔHR between CM PPM and GM LHR. HR changes followed the Gz profile, in that, as Gz increased, so did ΔHR, and as Gz decreased, ΔHR fell. Maximum and minimum ΔHR were similar for PPM and GM (PPM: +11.9 and -13.9 bpm; GM: +9.3 and -13.5 bpm). Peak ΔHR occurred after the maximum pull +Gz load in a similar fashion for both PPM and GM (first pull: 3.0 and 4.2 sec; second pull: 1.2 and 4.1 sec, PPM and GM, respectively). While the minimum ΔHR occurred, soon after minimum Gz was reached (after 0.7 and 1.6 sec, PPM and GM, respectively). The rate of increase in ΔHR during PPM was greater than GM during both pull phases of the LHR (first pull: 1.12 versus 0.82 bpm/sec (27% faster) and second pull: 5.64 versus 3.29 bpm/sec (42% faster), PPM and GM, respectively). During the push phase, it took longer for ΔHR to slow during PPM than it did for GM (PPM: -3.02 versus GM: -4.04 bpm/sec (33% slower)).

FUTURE MODE LOW/HIGH RAPID MANEUVER CHANGE IN HEART RATE

48. ANOVA results indicated that for PPM, the decrease in ΔHR during the push phase and the increase in ΔHR as a result of the pull following that push were significantly different than GM ($F = 3.12$, $p < 0.001$). Minimum ΔHR during the push was -28.2 bpm (PPM) and -10.3 (GM) and maximum ΔHR during the subsequent pull was +39.0 bpm (PPM) and +26.8 bpm (GM). During the push phase, GM ΔHR dropped quickly (-2.9 bpm/sec) then remained close to prerun levels (-3.7 ± 5.2 bpm) while at +1 Gz. Whereas ΔHR continued to fall during PPM, push at -4.1 bpm/sec, reached a minimum at -1 Gz and averaged -12.2 ± 10.1 bpm while at < +1 Gz. The rate of increase in ΔHR during the second pull was similar for both missions (PPM: +4.79 bpm/sec; GM: +4.48 bpm/sec). During the offset from the second pull, ΔHR declined 44% faster during PPM (PPM: -2.49 bpm/sec; GM: -1.40 bpm/sec). Figure 18 details the differences between PPM and GM LHR. Increases in ΔHR greater than 25 bpm are indicated above the green line.

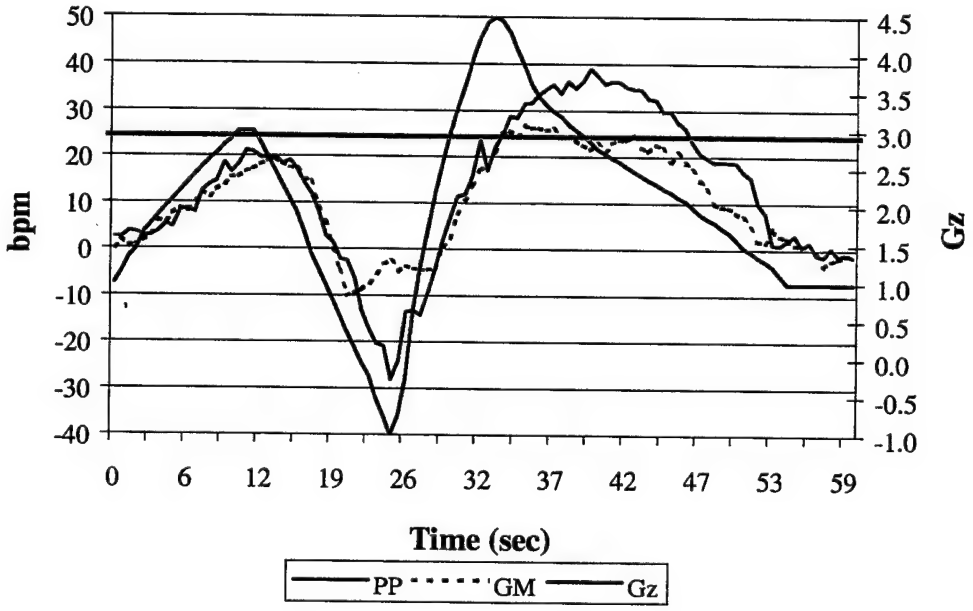

Figure 18
ΔHR DURING FM LHR MANEUVER

CURRENT MODE LOW/HIGH GRADUAL MANEUVER CHANGE IN HEART RATE

49. ANOVA results indicated that there were no statistically significant difference in ΔHR between CM PPM and GM LHG. As with LHR, HR changes followed the Gz profile. Maximum (during the second pull) and minimum (during the push phase) ΔHR were similar for PPM and GM (PPM: +16.1 and -14.8 bpm; GM: +14.9 and -9.6 bpm). During the push phase, the mean ΔHR for PPM was -8.1 ± 5.4 bpm and for GM it was -3.4 ± 3.6 bpm. Unlike the LHR, peak ΔHR was not delayed and occurred during the +3.5 Gz plateau for both PPM and GM. The rate

of ΔHR during the first pull, push, and offset from second pull phases was essentially the same for both missions. Whereas the rate of increase in PPM ΔHR during the second pull was 1.78 bpm/sec versus 1.09 bpm/sec for GM (39% difference).

FUTURE MODE LOW/HIGH GRADUAL MANEUVER CHANGE IN HEART RATE

50. ANOVA results indicated that for PPM, the decrease in ΔHR during the push phase was significantly different than GM ($F = 4.11$, $p < 0.001$). Minimum ΔHR during the push was -25.8 bpm (PPM) and -10.0 bpm (GM). Maximum ΔHR during the subsequent pull was essentially the same (PPM: +40.4 bpm; GM: +39.3 bpm). During the push phase, both PPM and GM ΔHR dropped quickly (-2.1 bpm/sec) and, while GM remained close to prerun levels (-2.3 ± 2.6 bpm), the average values during PPM push were much lower (-12.0 ± 10.0 bpm). The rate of increase in ΔHR during the second pull and the recovery from that pull were essentially the same during both missions (pull: PPM: 1.7 bpm/sec; GM: 1.6 bpm/sec; recovery: PPM: -3.5 bpm/sec; GM: -3.6 bpm/sec). Figure 19 details the differences between PPM and GM LHG. Increases in ΔHR greater than 25 bpm are indicated above the green line.

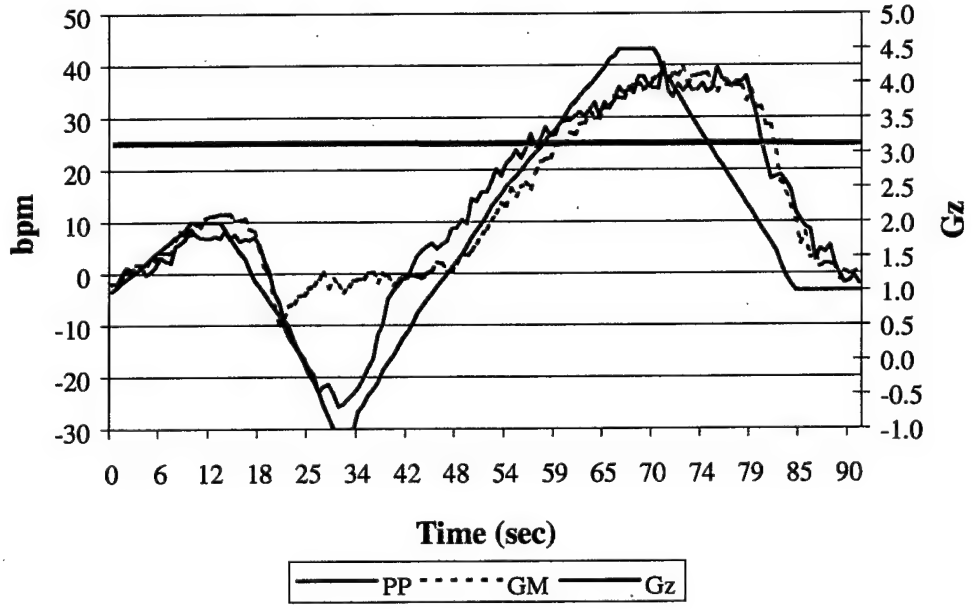

Figure 19
ΔHR DURING FM LHG MANEUVER

CURRENT MODE PUSHOVER CHANGE IN HEART RATE

51. In this maneuver, featuring a pull, push, pull, push, pull, recovery sequence, the Gz loads were modest as were the ΔHR. The push Gz transitions were small and there was an overall linear decline in mean ΔHR (PPM and GM at -4.0 bpm/sec), reaching a minimum during the

second push (PPM: -10.8 bpm; GM: -11.2 bpm). No statistical differences between PPM and GM ΔHR were found. While the peak ΔHR during the final pull was greater during the PPM, the difference was small (PPM: 10.6 bpm; GM: 7.8 bpm).

FUTURE MODE PUSHOVER CHANGE IN HEART RATE

52. With the increase in the Gz levels in this more aggressive PO, the extent to which ΔHR slowed during the push phases was significantly greater during PPM as compared to GM ($F = 4.28$, $p < 0.001$), as shown in figure 20. During this phase, the mean decrease in PPM ΔHR was -19.6 ± 2.9 bpm while GM ΔHR was -8.4 ± 2.8 bpm. Unlike the CM PO, there was a transient increase in PPM ΔHR (13.7 bpm) during the pull to +1 Gz between the two pushes. The peak ΔHR and the rate of increase to that peak during the final pull were greater during the PPM (PPM: 21.4 bpm at 4.1 bpm/sec; GM: 17.9 bpm at 2.6 bpm/sec).

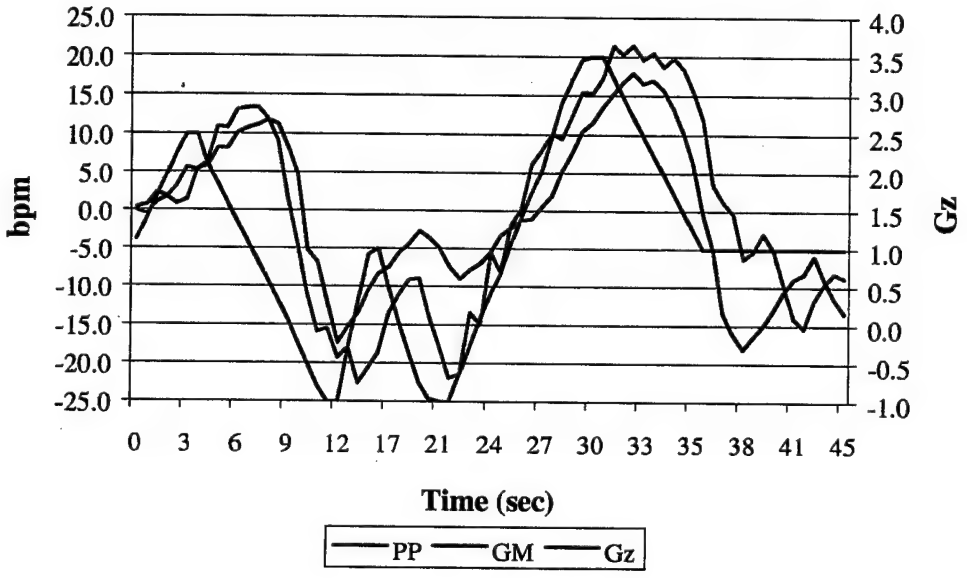

Figure 20
ΔHR DURING FM PO

CURRENT MODE MODIFIED LAZY EIGHT CHANGE IN HEART RATE

53. Changes in HR closely followed the complicated Gz pattern of the L8 maneuver. The overall drop in ΔHR was slightly greater during PPM (range: $-11.5 \leq \Delta HR \leq 8.7$ bpm) than GM (range: $-8.7 \leq \Delta HR \leq 9.0$ bpm), but no statistical differences between PPM and GM ΔHR were demonstrated.

FUTURE MODE MODIFIED LAZY EIGHT CHANGE IN HEART RATE

54. In a similar fashion to the current mode L8, changes in HR's closely followed Gz load. However, during the more aggressive version of the L8, the decrease in ΔHR during the push phase was significantly greater during PPM than GM ($F = 3.28$, $p < 0.001$). The mean ΔHR during the push was -17.8 ± 6.1 bpm and -3.1 ± 0.7 bpm, for PPM and GM, respectively. Following the push, there were two +3.5 Gz plateaus. PPM ΔHR during the second of these plateaus (29.9 ± 2.1 bpm) was significantly greater than GM (20.9 ± 1.3 bpm). Figure 21 details the differences between PPM and GM L8. Increases in ΔHR greater than 25 bpm are indicated above the green line.

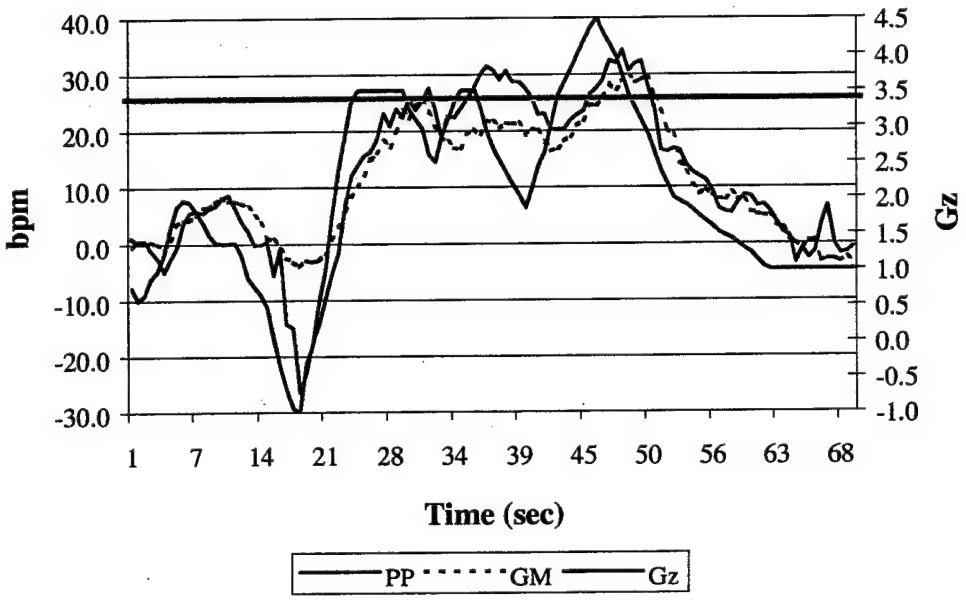

Figure 21
ΔHR DURING FM MODIFIED L8

ALMOST-LOSS OF CONSCIOUSNESS

55. There were four instances in which subjects reported symptoms consistent with the A-LOC syndrome. During his second PPM insert, subject V2 reported that he had a "harder time concentrating today." It was "harder to remember the profile details after about 15 min into the insertion." It "was frustrating." Subject N2 reported that he "did not feel clearheaded" during his second PPM insert. Subject V1, during his first GM exposure with the FM Loop maneuver, stated that he had a "warm feeling" accompanied by a "don't care attitude" which "came on suddenly." He reported that he was "not paying attention." The feeling passed by the end of the insert. The fourth incident occurred to subject V3 during his first GM exposure with the FM ROR3 maneuver. He reported being confused and "started to reach for the (stop the run) switch, but was unsure why" he wanted to.

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DISCUSSION

56. For an average male, mean SBP at heart level is 120 mmHg at 1 g. The heart must overcome an approximately 30 cm hydrostatic column for blood to reach the head. This corresponds to a hydrostatic pressure of about 22 mmHg. Therefore, at sea level, BP at the head is 98 mmHg. For each 1 g increase in applied +Gz stress, the hydrostatic column increases by about 30 cm, or head level pressure drops another 22 mmHg (reference 12). Light loss symptoms appear at approximately 50 mmHg head level BP (reference 13). Stauffer found that the onset of visual symptoms of 215 relaxed male subjects occurred on average at +3.7 Gz (reference 14). In a study using tilt table exposures, Schellong defined the onset of orthostatic hypotension as a ΔSBP of 21 mmHg or more (reference 15). Therefore, given the acceleration levels employed in this experiment, a decrease in ΔSBP measured at shoulder height of approximately 20 mmHg, which can be considered equivalent to a loss in G-tolerance of about 1 g, is considered a significant.

57. In a study examining the HR response of 30 male pilots to gradual onset acceleration exposures (the standard +Gz training profile which tends to maximally challenge the cardiovascular system), it was found the threshold for significant HR change was 25 bpm (reference 16). Therefore, the benchmark for operationally significant changes in heart for this study shall be 25 bpm.

58. The methodology presented in this report represents the first attempt to study the cardiovascular response to PPE utilizing acceleration loads and transitions based on actual in-flight profiles. BP and HR data analysis in which the effects of particular G transitions within a given maneuver could be tracked also represent a new approach. Changes in HR and BP are consistent with previous tactical in-flight measurements reported by Prior (reference 7).

59. CM: Reported PLL was trivial during all maneuvers within the acceleration capability of current rotary wing aircraft, except for the ROR. ROR light loss levels were relatively low (ranging from 10% to 30 deg or 40%) and subjects did not feel the need to strain to finish their runs. Note that when light loss was reported, it typically occurred during the transition between ≤ +1 Gz to higher +Gz loads. While PLL was low, modest decrements in visual field may become more significant when aircrew are wearing advanced helmet mounted displays. Often, individuals do not report that their visual field decreases from the periphery towards the center (classic PLL). In these cases, an overall graying or decrease in acuity is reported. For these individuals, it is possible that viewing certain symbology, colors, or intensities may be impaired.

60. There were no statistically significant differences in ΔSBP between PPM and GM for the maneuvers except the ROR. Peak ΔSBP for all maneuvers were well below 20 mmHg, reaching a maximum decrease of 12.8 mmHg during the third ROR. There were indications that the cardiovascular system of the subjects were being taxed during the 25 min CM mission based on the statistically significant declines in ROR ΔSBP over time. Even though there were some differences between PPM and GM demonstrated, the magnitude of the changes in SBP may not be operationally significant.

61. Mirroring the trend displayed in the ΔSBP results, only the differences in ΔHR between PPM and GM measured during ROR maneuvers were statistically significant. The overall magnitude of ΔHR between the minimum level during the ROR push and maximum reached during the ROR pull were physiologically significant (maximum range in ΔHR was 35.3 and 31.7 bpm, PPM and GM, respectively). Other maneuvers in which the overall swing in ΔHR was above the threshold were the low/high maneuvers (LHR: PPM = 25.8 bpm, GM = 22.8 bpm; LHG: PPM = 30.9 bpm, GM = 25.5 bpm). The cardiovascular system did respond to the applied stress by increasing ΔHR more quickly during PPM as compared to GM maneuvers.

62. Given the relatively low change in SBP and the low levels of reported light loss, the cardiovascular compensation shown during these relatively low levels of acceleration exposures, as manifest by the change in HR, is probably sufficient to enable aircrew to tolerate these exposures. This would apply for relatively short missions for aircrew who are sufficiently hydrated. However, given that there were measurable differences in the cardiovascular response between PPM and GM and the apparent increase in that response as G exposure time increased, it is possible that aircrew on longer missions may be at risk. Specific data would have to be collected for longer exposures and include determining the effects of varying hydration levels, impact of increased thermal burden associated with wearing protective garments, and the effect of PPE on cognition and psychomotor responses.

63. FM: Loss of vision was considerably greater during the FM mission as compared to the CM. Light loss during PPM was greater than during GM and the level of muscular tensing required to keep subjects' vision clear was also marginally greater during PPM. Again, the greatest reported light loss occurred during the transition between low to high levels of Gz stress, particularly during the maneuvers with the greatest differentials, such as the ROR and Low/High runs.

64. The decrease in SBP was significantly greater during PPM ROR and PO maneuvers when compared to GM. These differences occurred during the large pull following the push phase in both maneuvers. Furthermore, as the time at G increased, the drop in ΔSBP is also significantly greater, as was demonstrated by comparing the second GOR with the first and the second and third ROR with the first. During the ROR, peak declines in ΔSBP were above 20 mmHg for both PPM and GM, indicating that G-tolerance declined by approximately 1 g. Overall, peak drop in ΔSBP during maneuvers other than GOR ranged from -13.1 to -21.4, a drop in G-tolerance from about 0.6 to 1 g. Of interest was the observation that the decline in ΔSBP during the LHR

maneuver was greater than during the LHG maneuver. This is probably a result of the longer period of time during the LHG maneuver to invoke a greater cardiovascular compensatory response than during the LHR maneuver.

65. During the FM runs, ΔHR during the PPM was statistically greater than during the GM, for ROR, LHR, LHG, PO, and L8 maneuvers. ΔHR increased as time at G increased for both ROR and GOR runs. The peak overall change in ΔHR was physiologically significant and was as follows: LHR: 67.2 bpm (PPM), 37.0 bpm (GM); LHG: 66.4 bpm (PPM), 49.3 bpm (GM); PO: 44.0 bpm (PPM), 36.0 bpm (GM); ROR: 46.5, 50.3, 52.6 bpm (PPM runs 1, 2, 3, respectively) and 49.9, 44.4, 50.1 bpm (GM runs 1, 2, 3, respectively); and GOR: 38.7, 43.1 bpm (PPM runs 1, 2, respectively), and 45.9, 42.2 bpm (GM runs 1, 2, respectively).

66. Given the physiologic responses to the stresses developed during FM exposures (relatively large decrease in SBP, significant increase in HR, loss of peripheral vision, incidences of possible A-LOC symptoms, and the increased need for muscular tension), aircrew exposed to acceleration loads developed by more aggressive platforms are at a greater risk than when flying less aggressive platforms. Furthermore, exposures to push-pull maneuvers may have a somewhat greater risk than exposures to purely +Gz loads. Subjects noted that they felt a greater fatigue after the PPM as compared to the GM. In some instances, subjects' vision decreased to 90 deg. However, given that all runs were completed without the need for performing anti-G straining maneuvers or with the support afforded by anti-G suits, indicates that these types of exposures are tolerable within the parameters set by this experiment. That is, an overall 60 min limit and exposure to the higher loads during the last half hour by subjects who are euhydrated. Additional tests for longer duration times involving different hydration states are required to better address the risks.

67. The findings of this study have important implications in the fixed wing tactical community as well. The significant changes in cardiovascular response, loss of visual field, and incidence of A-LOC episodes at these relatively low G levels could be expected to increase during tactical missions during which pulls may reach +7.5 to 9 Gz. In particular, the areas of helmet mounted displays, aircrew protection, and tactics may benefit from these data.

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CONCLUSIONS

GENERAL

68. Within the scope of these tests, subjects had little difficulty tolerating the range of acceleration stresses associated with platforms currently employed in the U.S. Navy inventory. As the capabilities of those platforms increase to include -1 Gz through +4.5 Gz (within the capabilities of current U.S. Army platforms), the cardiovascular stress significantly increases and the ability to tolerate the Gz loads decreases. Aircrew may be at increased risk as the length of high performance rotary wing missions increases if aircrew are not given adequate training in this environment.

SPECIFIC

PERIPHERAL LIGHT LOSS

69. CM light loss levels were trivial. However, there was significant loss of peripheral vision reported during FM maneuvers, with loss during the PPM greater than during the GM (paragraphs 24 and 25).

FATIGUE AND NAUSEA

70. Despite statistically greater estimates of subjective fatigue and nausea during the FM as compared to the CM mission, reported levels were not operationally meaningful (rated between "nothing and noticeable") (paragraph 27).

CARDIOVASCULAR RESPONSE: CURRENT MODE

71. The effects of cumulative acceleration stress were demonstrated by larger decreases in ΔSBP during succeeding ROR and GOR maneuvers. Larger declines in ΔSBP were associated with PPM as compared to GM ROR exposures. Peak decreases in ΔSBP during the third ROR led to a drop in predicted acceleration tolerance, based on the hydrostatic column theory, of 0.6 g (PPM) and 0.4 g (GM) and only 0.2 g (PPM) and 0.25 g (GM) during the GOR (paragraphs 30 and 32).

72. There were no statistically significant differences demonstrated in ΔSBP between PPM and GM modes for LHR, LHG, PO, or modified L8 maneuvers. Peak decreases in ΔSBP represent minor reductions in predicted acceleration tolerance, based on the hydrostatic column theory: LHR = 0.3 g; LHG = 0.4 g; PO = 0.2 g (PPM), 0.1 g (GM); L8 = 0.2 g (paragraphs 34, 36, 38, and 40).

73. The magnitude of changes in HR during ROR maneuvers for the PPM was significantly different from the GM, primarily due to the greater drop in HR during the period at +0.6 Gz during PPM, and the ensuing rise in HR during the subsequent pull was faster after the period below +1 Gz. Total mean change in HR (from push to pull phase) was just over the operationally significance threshold (approximately 31 bpm) (paragraph 43).

74. There were no significant differences in ΔHR for GOR, LHR, LHG, PO, and L8 maneuvers between PPM and GM. The overall swing in HR during GOR, PO, and L8 was not operationally significant, while the range in ΔHR did just cross the threshold for PPM LHR (26 bpm) and LHG (31 and 26 bpm, PPM and GM, respectively) (paragraphs 45, 47, 49, 51, and 53).

CARDIOVASCULAR RESPONSE: FUTURE MODE

75. The cardiovascular response to acceleration stress was amplified during the more aggressive maneuver simulation. There were statistically significant differences in the response to PPM versus GM ROR maneuvers. ΔSBP fell more rapidly to a greater extent during PPM after the excursion to +0.6 Gz. Peak decreases in PPM during ROR would be reflected in a estimated drop in acceleration tolerance of 1.1 g (GM) to 1.2 g (PPM) (paragraph 31).

76. There was a statistically significant greater drop in ΔSBP during the second GOR during both PPM and GM, indicating the effects of cumulated G stress. However, the predicted drop in G tolerance was on the order of 0.6 g (GM) to 0.7 g (PPM) (paragraph 33).

77. No statistically significant difference in ΔSBP between PPM and GM was demonstrated for LHR, LHG, L8. However, the decrease in PPM ΔSBP during the PO maneuver was significantly greater than GM. Estimated reduction in G tolerance was: LHR = 0.8 g (PPM) and 1.0 g (GM); LHG = 0.7 g; PO = 0.8 g (PPM) and 0.7 g (GM); L8 = 0.7 g (PPM) and 0.6 g (GM) (paragraphs 35, 37, 39, and 41).

78. Changes in HR during all simulated aggressive push-pull helicopter maneuvers were significantly greater than those recorded during the GM. The rise in HR during the last ROR and GOR was significantly higher than the first, another indication of the effects of cumulative G stress. In all cases, the overall increases in HR were well over the 25 bpm threshold. The largest ΔHR occurred during the PPM LHR (67 bpm), LHG (66 bpm), and L8 (61 bpm) (paragraphs 44, 46, 48, 50, 52, and 54).

ALMOST-LOSS OF CONSCIOUSNESS

79. Four separate instances of A-LOC occurred, two during PPM and two during GM. In each case, subjects reported deficits in the ability to concentrate. This may indicate the potential for performance degradation during rotary wing flight due to unprotected exposures to acceleration stress - even at the relatively low levels associated with helicopter maneuvers (paragraph 55).

RECOMMENDATIONS

80. Establish training program for rotary wing aviators about the potential hazards of acceleration loads (both greater than and less than +1 Gz), including loss of vision and the use of muscular tensing/straining or breathing patterns to restore vision, and the potential for A-LOC (paragraphs 24, 25, 63, and 69).

81. No equipment modifications or additional protective garments are recommended (paragraphs 62 and 68).

82. Investigate effects on physiological responses and cognitive and psychomotor performance of cumulative acceleration stress during longer simulated missions based on operational needs (paragraphs 62 and 66).

83. Investigate effects of dehydration on ability to tolerate rotary wing acceleration stress, including the use of operational flight gear, and life support equipment, such as antiexposure garments, CBR protection, and body armor (paragraphs 3, 62, and 66).

84. Use the techniques employed in this study to investigate the effects of the PPE at levels developed during fixed wing tactical maneuvers on physiologic responses and performance (paragraph 67).

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REFERENCES

1. Taliaferro, E.H.; Wempen, R.R.; White, W.J.; The Effects of Minimal Dehydration Upon Human Tolerance to Positive Acceleration, Aerospace Med., 1965; 36:922-6.

2. Allan, J.R.; Crossley, R.J.; Effect of Controlled Elevation of Body Temperature on Human Tolerance to +Gz Acceleration, J. Appl. Physiol., 1972; 33:418-20.

3. Mohler, S.R., G Effects on the Pilot during Aerobatics, Technical Report FAA-AM-72-28, Washington DC:Federal Aviation Administration, 1972; 1-19.

4. Von Beckh, H.J., Experiments with Animals and Human Subjects Under Sub- and Zero-Gravity Conditions during the Dive and Parabolic Flight, Aviation Med., 1954; 25:235-241.

5. Von Beckh, H.J., Human Reactions during Flight to Acceleration Preceded by or Followed by Weightlessness, Aerospace Med., 1959; 30:391-409.

6. Lehr, A-K; Prior, A.R.J.; Langewouters, G.; Ullrich, B.; Leipner, H.; Zollner, S.; Linder, P.; Pongratz, H.; Dieterich, H.A.; Theisen, K.; Previous Exposure to Negative Gz Reduces Relaxed +Gz Tolerance (Abstract), Aviat. Space Environ. Med., 1992; 63:405.

7. Prior, A.R.J.; Adcock, T.R.; McCarthy, G.W.; In-flight Arterial Blood Pressure Changes during -Gz to +Gz Maneuvering (Abstract), Aviat. Space Environ. Med., 1993; 64:428.

8. Self, D.A.; Hainsworth, R.; Krock, L.P.; Christopher, P.A.D.; Latham, R.D.; An Acute Animal Model that Simulates the Hemodynamic Situations Present during +Gz Acceleration, Aviat. Space Environ. Med., 1994; 65(5, Suppl.):A80-9.

9. Nelson, J.G., Hydrostatic Theory and G Protection Using Tilting Aircrew Seats, Aviat. Space Environ. Med., 1994; 1987; 58:169-73.

10. Angel, S.M.; Marley, R.J.; Stadtlander, L.; Perceived Exertion Scales: Toward Development of Improved Verbal Anchors, Proc. Human Factors & Ergonomics Soc. 38th Annual Meeting, 1994; p 626-30.

11. Wright, H.; Buick, F.; The +Gz-Tolerance Limits of the Push-Pull Phenomenon, Proceedings of 69th Annual Scientific Meeting of the Aerospace Medical Association, Seattle, WA, May 17-21, 1998, p. 56.

12. Shender, B.S., Application of Rheoencephalography to Study Physiological Responses Under Acceleration Stress, NADC Technical Report NADC-91127-60, Warminster:Naval Air Development Center, of 1 Sep 1991.

13. Wood, E.H.; Lambert, E.H.; Objective Documentation and Monitoring of Human Gz Tolerance When Unprotected and When Protected by Anti-G Suits or M-1 Type Straining Maneuvers Alone or in Combination, SAFE Journal, 1989:19, 39-48.

14. Stauffer, F.R., Acceleration Problems of Naval Air Training: I, Normal Variations in Tolerance to Positive Radial Acceleration, Research Report NM 001 059.02.09, USN School of Aviation Medicine, Pensacola, of 20 Mar 1952.

15. Schellong, F., Regulationsprufung des Kreislaufes Darmstadt, Steinkopf, 1954.

16. Forster, E.M., Heart Rate Response of Aircrew during Recovery from Gradual Onset Rate +Gz Exposures, Aviat. Space Environ. Med., 1994; 65:55-9.

APPENDIX A
TABLES

Table A-1a
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING THREE CM ROR PPM MANEUVERS

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
0.0	0.72	0.78	0.80	0.40	-0.23	1.53	-1.11
0.6	0.66	0.39	1.37	0.19	-0.61	2.08	-1.45
1.2	0.61	0.47	1.95	0.32	-2.20	1.10	-1.43
1.8	0.60	0.77	-0.40	0.49	-2.92	1.40	-1.54
2.5	0.60	0.80	-4.29	1.05	-4.21	1.37	-3.33
3.1	0.60	1.99	-3.65	1.57	-2.12	1.80	-4.93
3.7	0.60	2.44	-4.86	1.38	-3.39	1.48	-5.54
4.4	0.60	1.64	-4.68	1.14	-4.94	1.83	-5.27
5.0	0.60	1.37	-4.81	1.35	-4.92	1.58	-5.98
5.7	0.60	1.37	-4.12	1.40	-5.78	1.53	-4.88
6.3	0.63	0.88	-2.80	1.54	-5.10	1.78	-4.49
7.0	0.71	0.83	-2.26	1.11	-3.78	2.13	-5.18
7.6	0.77	1.18	-0.74	0.81	-2.72	1.64	-5.66
8.2	0.83	0.91	-3.08	1.19	-2.22	1.64	-3.95
8.8	0.88	0.94	-0.21	0.57	-2.61	0.91	-3.30
9.4	0.94	0.12	-0.86	0.19	-1.66	1.42	-2.15
10.0	0.99	-0.12	-1.71	0.16	-0.87	1.18	-2.33
10.6	1.74	-2.13	0.69	-1.98	-3.06	-0.91	-3.56
11.2	2.56	-4.33	5.38	-4.86	1.38	-5.63	0.17
11.8	3.21	-6.23	8.30	-7.95	7.00	-11.65	5.46
12.3	3.50	-7.12	11.63	-9.83	9.91	-12.30	9.80
12.9	3.37	-7.64	15.86	-11.02	11.77	-12.85	10.41
13.4	3.16	-8.07	15.65	-10.85	14.62	-11.63	12.78
13.9	2.87	-6.58	20.44	-9.23	17.03	-11.65	15.69
14.5	2.58	-6.17	20.77	-8.25	18.61	-11.11	18.08
15.0	2.32	-7.23	21.02	-8.11	17.16	-10.13	17.00
15.5	2.07	-6.36	21.00	-8.82	18.61	-10.22	18.64
16.0	1.53	-6.17	22.01	-9.12	20.60	-9.73	19.55
16.5	1.27	-5.90	22.04	-8.87	19.31	-10.11	19.65
17.0	0.99	-5.28	20.10	-8.14	19.68	-9.08	19.81
17.5	0.72	-4.87	20.31	-6.16	16.29	-8.24	17.37
18.0	0.76	-3.70	20.30	-4.29	14.48	-5.98	13.01
18.5	0.98	-2.79	14.06	-3.33	5.74	-4.00	7.47
19.0	1.05	-1.20	7.24	-1.76	1.61	-2.40	2.81
19.5	1.01	0.65	-0.73	-0.55	-1.09	-2.21	-3.85
21.1	1.00	3.29	-4.18	1.16	-6.01	-1.02	-6.49
21.7	1.00	4.63	-5.40	2.60	-7.48	0.01	-6.16
22.4	1.00	4.76	-4.57	3.03	-9.65	0.66	-7.79
23.0	1.00	5.06	-6.21	3.93	-14.73	0.77	-9.38
23.7	1.00	5.39	-7.34	3.98	-14.72	0.96	-10.33
24.4	1.00	4.63	-6.44	4.74	-13.12	1.26	-9.23
25.2	1.00	4.71	-5.56	3.52	-12.26	0.53	-7.00
25.8	1.00	3.46	-3.51	3.61	-10.44	1.26	-2.23
26.5	1.00	3.41	-0.24	4.26	-6.74	0.26	-2.86
27.2	1.00	3.49	-1.05	2.74	-7.88	0.61	-4.63
27.8	1.00	3.41	-2.59	2.38	-7.88	0.80	-4.59
28.5	1.00	2.13	-3.19	3.09	-8.60	1.23	-5.80
29.1	1.00	2.88	-0.44	2.91	-8.49	1.25	-4.24

Table A-1b
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING THREE CM ROR GM MANEUVERS

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
0.0	1.00	3.02	-0.82	0.59	-0.95	0.74	-0.96
0.7	1.00	2.58	0.76	-0.19	1.96	0.87	-2.04
1.5	1.00	2.26	1.97	-0.93	1.49	0.37	-2.71
2.2	1.00	2.72	0.43	-0.66	0.93	0.12	-1.74
2.9	1.00	3.48	-1.15	0.05	0.01	1.18	-1.02
3.6	1.00	3.34	-1.42	0.27	-0.88	0.97	-0.81
4.3	1.00	3.34	-1.45	0.35	-1.20	1.46	-1.77
5.0	1.00	3.07	-3.25	-0.77	-3.33	1.24	-3.93
5.7	1.00	2.74	-2.57	-0.22	-1.04	1.21	-4.78
6.4	1.00	3.32	-1.00	-0.38	-0.48	1.62	-4.12
7.2	1.00	2.31	0.07	-0.49	0.26	0.88	-3.03
7.9	1.00	2.72	0.77	-0.76	1.77	0.88	-0.91
8.6	1.00	2.28	0.91	-0.66	2.44	0.29	0.11
9.3	1.00	1.85	0.91	0.00	0.33	0.83	-1.02
10.0	1.00	2.72	-0.95	0.00	-0.19	0.96	-1.23
10.8	1.00	2.50	-0.05	-0.09	2.50	0.23	-0.88
11.5	1.00	2.72	-0.56	-0.85	1.83	0.31	-1.87
12.2	1.40	1.82	0.85	-0.74	2.45	-0.61	-0.44
12.9	2.10	1.96	3.70	-0.93	4.25	-3.46	1.43
13.6	2.80	-0.62	8.89	-3.26	8.11	-6.71	6.48
14.3	3.50	-1.05	7.12	-5.70	10.23	-7.66	7.55
15.0	3.50	-2.16	12.08	-6.60	11.63	-7.80	9.72
15.6	3.20	-1.76	13.16	-6.03	13.59	-6.68	12.10
16.2	2.90	-3.57	14.07	-5.89	14.83	-6.33	12.70
16.8	2.60	-3.79	17.00	-6.22	16.47	-6.49	16.47
17.3	2.20	-2.73	16.63	-5.89	17.89	-5.27	15.24
17.9	1.85	-2.52	17.21	-6.57	18.22	-5.16	16.55
18.5	1.55	-2.84	16.56	-6.30	18.67	-4.54	15.74
19.0	1.25	-3.90	17.43	-6.25	18.52	-4.22	14.17
19.6	1.00	-3.79	17.00	-6.38	18.25	-3.81	11.54
20.1	1.00	-3.22	16.55	-5.08	15.13	-3.40	6.49
20.6	1.00	-2.06	14.23	-2.96	12.41	-2.78	0.62
21.2	1.00	-0.89	12.48	-1.36	7.97	-0.42	0.27
21.7	1.00	-0.08	8.45	-0.28	2.29	-0.38	-5.51
22.4	1.00	0.69	0.61	-0.25	-6.84	-0.06	-9.03
23.2	1.00	2.34	-8.40	2.14	-9.89	1.21	-9.90
24.1	1.00	3.59	-10.60	2.81	-9.15	1.24	-9.89
24.9	1.00	4.02	-12.95	2.33	-7.77	1.59	-9.38
25.7	1.00	4.13	-13.42	2.52	-8.86	0.97	-9.24
26.5	1.00	3.75	-14.31	3.52	-7.85	0.13	-10.04
27.3	1.00	3.50	-12.55	3.22	-6.46	0.88	-8.26
28.1	1.00	4.05	-9.34	2.79	-7.57	0.91	-6.81
28.9	1.00	3.64	-5.20	2.69	-6.38	0.48	-5.75
29.7	1.00	2.94	-3.22	2.91	-6.03	0.27	-4.42
30.5	1.00	2.61	-2.19	1.67	-7.18	0.14	-3.00
31.3	1.00	3.04	-1.26	2.65	-6.91	0.21	-2.70
32.1	1.00	2.51	0.56	2.47	-7.33	0.90	0.22

Table A-2
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING TWO CM GOR MANEUVERS

		PPM				GM			
Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2
0.0	1.05	-1.14	0.53	-0.35	-0.42	0.89	-1.94	0.21	1.54
0.7	1.19	-0.92	0.17	-0.71	-2.15	0.24	0.15	-0.20	0.16
1.4	1.26	-0.57	0.57	-1.30	-1.92	0.26	-0.67	-0.20	0.26
2.1	1.33	-0.19	-0.40	-1.60	-1.18	-0.06	-0.58	-0.14	-1.75
2.8	1.40	-1.08	-0.43	-1.76	0.84	-0.03	0.39	0.46	-0.10
3.6	1.47	-1.11	0.20	-1.38	2.26	0.24	2.28	0.81	-0.48
4.3	1.55	-0.46	0.99	-2.11	1.34	-0.55	2.24	-0.06	-1.09
5.0	1.61	-0.25	0.11	-2.50	2.88	-0.19	1.52	0.05	1.18
5.7	1.67	-0.57	0.80	-1.90	4.50	-0.28	1.14	-1.55	2.03
6.3	1.73	-0.70	-0.14	-2.71	3.97	-0.82	2.73	-2.64	2.27
6.9	1.80	-1.52	2.40	-2.17	1.94	-1.58	4.35	-2.12	2.44
7.6	1.86	-2.14	3.78	-1.36	1.50	-0.85	5.42	-2.18	2.35
8.3	1.93	-2.14	2.65	-1.95	1.04	-1.23	5.81	-1.34	3.52
8.9	1.99	-1.95	3.29	-2.77	2.07	-1.36	5.16	-1.18	4.42
9.6	2.04	-1.30	2.86	-3.12	3.09	-1.96	6.60	-1.85	5.20
10.2	2.11	-1.06	3.36	-2.74	4.68	-2.07	6.51	-2.99	6.46
10.9	2.17	-1.41	4.43	-3.58	6.90	-2.31	8.21	-3.99	5.85
11.5	2.24	-2.01	2.18	-3.28	6.98	-2.31	8.38	-3.37	6.90
12.1	2.30	-1.84	4.87	-4.07	7.71	-1.93	8.97	-2.99	6.71
12.7	2.36	-1.52	3.78	-3.82	8.02	-2.42	10.29	-2.53	7.17
13.4	2.43	-1.17	5.20	-3.71	7.46	-2.64	9.93	-2.72	8.91
14.0	2.48	-1.70	7.33	-3.85	8.11	-2.01	12.16	-4.67	8.57
14.6	2.50	-1.68	4.47	-3.99	9.17	-2.69	10.63	-4.21	9.42
15.2	2.50	-1.36	6.09	-4.02	9.61	-2.47	11.33	-4.10	9.23
15.8	2.50	-1.76	6.29	-4.42	10.35	-2.31	12.39	-4.46	8.76
16.5	2.50	-3.47	6.94	-4.10	9.17	-3.40	12.34	-3.78	8.37
17.1	2.50	-3.16	6.16	-2.17	9.13	-3.34	11.97	-4.73	8.95
17.8	2.51	-2.60	8.45	-3.12	9.51	-3.45	12.21	-3.56	7.87
18.4	2.47	-2.33	7.76	-4.22	8.67	-2.43	11.55	-3.45	10.40
19.1	2.38	-3.01	6.53	-3.53	10.92	-2.61	11.36	-4.84	8.08
19.7	2.23	-3.02	7.90	-3.34	10.06	-3.13	10.76	-4.89	8.98
20.3	2.10	-2.33	8.55	-2.90	9.37	-2.42	10.11	-4.67	9.36
20.9	1.99	-1.33	6.55	-2.23	8.21	-1.55	9.17	-3.91	9.23
21.6	1.87	-1.30	5.47	-3.01	9.06	-2.07	8.57	-3.78	8.10
22.2	1.75	-1.32	7.89	-3.11	7.07	-2.18	9.47	-4.57	7.46
22.9	1.62	-0.24	5.88	-2.77	7.71	-2.01	7.44	-4.84	7.27
23.5	1.50	-0.95	4.16	-1.90	8.50	-1.63	6.52	-3.99	6.99
24.2	1.37	-0.24	3.92	-1.14	5.99	-1.53	6.12	-4.51	6.58
24.8	1.24	0.21	3.74	-0.46	3.82	-1.72	5.41	-5.57	3.47
25.5	1.13	0.29	1.75	-0.30	1.34	-1.91	3.46	-3.40	1.80
26.3	1.07	0.90	1.45	-0.11	2.55	-0.63	1.60	-2.80	-1.54
27.0	1.05	1.28	0.35	0.14	2.35	0.13	-1.06	-1.05	-5.25
27.8	1.00	2.16	0.41	0.41	-0.82	0.21	-4.53	-0.17	-10.86
28.5	1.00	2.95	-2.53	1.30	-2.12	0.70	-4.01	0.97	-10.58
29.3	1.00	3.44	-2.18	1.08	-3.26	1.35	-5.44	-0.71	-11.17
30.2	1.00	3.47	-2.39	0.03	-5.35	1.97	-6.55	-0.57	-9.64
31.0	1.00	3.42	-2.58	0.73	-5.90	2.08	-5.66	-0.69	-4.71

Table A-2 (Cont'd)

		PPM				GM			
Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2
31.7	1.00	3.69	-0.68	0.16	-5.15	2.06	-7.43	-0.79	-3.09
32.5	1.00	2.77	-2.44	0.84	-5.10	2.38	-7.45	-1.66	-2.48
33.3	1.00	3.50	-2.19	0.60	-5.21	2.08	-6.39	-0.74	-0.96
34.0	1.00	3.53	-4.32	0.89	-6.33	1.97	-5.25	-0.93	-1.77
34.7	1.00	3.53	-5.22	1.11	-5.24	2.03	-3.92	-0.84	-1.50
35.4	1.00	3.04	-6.78	1.14	-4.14	1.59	-4.75	-0.69	-3.15
36.2	1.00	3.52	-6.13	0.42	-2.81	1.13	-6.25	-0.97	-4.39
36.9	1.00	3.27	-6.32	0.26	-2.79	1.84	-7.27	-0.88	-3.46
37.6	1.00	3.20	-6.02	0.63	-3.35	1.80	-7.80	-0.84	-3.53

Table A-3
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING CM LHR MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.00	-0.48	-1.81	1.00	1.23	-0.75
0.6	1.12	-0.69	-1.34	1.12	1.58	-0.69
1.3	1.25	-0.74	-0.48	1.25	1.26	0.22
1.9	1.36	-1.00	-0.72	1.36	1.10	0.54
2.5	1.46	-1.20	1.49	1.46	0.91	-1.59
3.1	1.56	-1.99	1.49	1.56	0.99	-1.77
3.7	1.68	-2.78	3.96	1.68	0.01	0.58
4.3	1.79	-3.84	3.49	1.79	-1.37	2.51
5.0	1.86	-3.67	2.93	1.86	-1.89	2.06
5.6	1.90	-4.33	3.79	1.90	-1.67	4.16
6.2	1.70	-4.00	4.74	1.70	-2.02	3.58
6.8	1.50	-3.93	4.71	1.50	-2.19	3.57
7.4	1.30	-3.65	5.87	1.30	-1.67	4.63
8.0	1.10	-3.24	6.16	1.10	-2.32	5.39
8.6	0.90	-3.64	5.94	1.00	-2.57	5.21
9.1	0.70	-3.22	6.20	1.00	-1.59	4.80
9.8	0.50	-2.62	3.91	1.00	-1.65	2.43
10.4	0.30	-3.00	-2.01	1.00	-0.88	-1.73
11.0	0.10	-2.16	-6.18	1.00	-0.07	-2.77
11.7	-0.10	-0.50	-7.51	1.00	0.09	-6.54
12.3	0.15	-0.05	-10.86	1.00	0.45	-7.74
13.1	0.26	0.38	-13.88	1.00	0.31	-9.48
13.9	0.77	1.73	-13.81	1.00	-0.02	-13.54
14.7	1.30	0.14	-13.16	1.30	0.11	-11.77
15.5	1.76	-0.94	-12.12	1.76	-0.99	-8.10
16.2	2.21	-1.34	-9.00	2.21	-2.49	-4.32
16.9	2.60	-4.68	-1.30	2.60	-4.52	-1.61
17.7	2.85	-6.33	1.54	2.85	-6.39	2.77
18.4	3.00	-7.33	5.86	3.00	-7.29	5.27
19.0	2.82	-6.98	7.37	2.82	-7.31	5.51
19.6	2.55	-6.82	11.95	2.55	-7.31	6.08
20.1	2.25	-6.28	10.69	2.25	-7.12	7.78
20.7	1.99	-4.41	10.93	1.99	-6.88	8.49
21.3	1.85	-3.92	11.71	1.85	-5.96	7.90
21.9	1.81	-4.60	10.88	1.81	-4.52	8.10
22.4	1.74	-4.84	10.19	1.74	-4.76	9.34
23.0	1.65	-4.22	9.78	1.65	-3.87	7.73
23.6	1.57	-3.43	10.53	1.57	-3.38	5.74
24.2	1.49	-2.94	8.04	1.49	-3.00	5.10
24.8	1.41	-2.59	8.40	1.41	-2.95	2.59
25.3	1.34	-2.43	7.36	1.34	-2.32	1.64
26.0	1.26	-3.03	6.22	1.26	-1.18	-1.16
26.6	1.17	-2.92	3.65	1.17	-1.16	-0.82
27.2	1.09	-1.99	2.85	1.09	-2.54	-6.45
27.8	1.00	-1.53	1.26	1.00	-0.02	-5.95
28.4	0.98	-1.80	-4.13	0.98	0.90	-7.01
29.0	0.99	-0.42	-3.05	0.99	1.17	-7.19

Table A-3 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
29.6	1.00	-0.72	-4.02	1.00	1.09	-7.52
30.2	1.00	-0.42	-6.10	1.00	0.83	-8.06
30.8	1.00	0.61	-4.32	1.00	1.80	-7.27
31.4	1.00	-0.34	-5.50	1.00	1.61	-7.13
32.0	1.00	0.12	-4.73	1.00	1.37	-7.90
32.6	1.00	0.69	-4.45	1.00	1.12	-5.89
33.2	1.00	0.63	-5.44	1.00	1.15	-7.57
33.9	1.00	0.79	-5.34	1.00	1.18	-6.56
34.5	1.00	0.55	-4.06	1.00	0.42	-7.17
35.2	1.00	1.04	-3.27	1.00	0.55	-7.26

Table A-4
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING CM LHG MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.00	-0.58	-2.30	1.00	1.54	-1.17
0.7	1.07	-0.03	-1.52	1.07	0.32	-1.57
1.4	1.14	-0.28	-0.10	1.14	1.05	-1.29
2.0	1.20	-0.20	-0.31	1.20	1.11	-0.49
2.7	1.27	-0.33	-1.32	1.27	0.48	-1.05
3.4	1.34	-0.01	-1.80	1.34	0.67	-3.05
4.1	1.40	-0.93	-2.87	1.40	1.21	-2.06
4.8	1.40	-0.68	-2.17	1.40	-0.28	-1.14
5.5	1.40	-1.48	-0.99	1.40	-1.45	0.31
6.2	1.40	-2.12	0.52	1.40	-1.39	0.54
6.8	1.40	-2.69	1.66	1.40	-0.94	0.96
7.5	1.40	-2.56	2.27	1.40	-0.77	1.21
8.2	1.40	-2.92	3.89	1.40	-0.70	1.40
8.8	1.26	-2.72	3.40	1.26	-1.80	3.43
9.5	1.13	-2.18	2.11	1.13	-1.91	4.10
10.2	0.99	-2.65	1.61	1.00	-0.44	3.65
10.9	0.85	-2.50	-0.60	1.00	-0.52	2.04
11.6	0.70	-1.71	-1.41	1.00	0.43	-0.71
12.3	0.56	-2.00	-5.29	1.00	0.37	-4.29
13.1	0.40	-0.85	-6.96	1.00	0.83	-3.59
13.8	0.26	-1.25	-8.16	1.00	0.56	-5.97
14.5	0.26	-0.63	-10.88	1.00	0.24	-8.21
15.3	0.26	-0.03	-13.35	1.00	1.32	-7.76
16.0	0.39	0.19	-14.78	1.00	1.32	-5.47
16.8	0.53	0.43	-13.85	1.00	0.73	-6.15
17.6	0.65	1.61	-12.40	1.00	-0.25	-4.15
18.3	0.78	1.81	-10.63	1.00	-0.86	-2.40
19.1	0.91	0.40	-9.22	1.00	-0.48	-1.29
19.8	1.04	-0.42	-7.93	1.04	-0.07	-0.90
20.5	1.15	-0.75	-7.57	1.15	0.13	0.07
21.2	1.27	-1.65	-7.87	1.27	-0.04	-0.25
21.9	1.39	-2.24	-6.87	1.39	-0.36	-1.17
22.6	1.50	-2.83	-3.37	1.50	-0.12	-0.89
23.2	1.62	-3.86	-1.68	1.62	-0.89	1.87
23.9	1.73	-3.94	1.74	1.73	-1.99	3.00
24.6	1.84	-4.53	3.54	1.84	-1.77	4.76
25.2	1.95	-4.32	4.89	1.95	-2.20	4.09
25.8	2.06	-5.35	6.88	2.06	-2.75	3.57
26.5	2.16	-5.70	7.77	2.16	-3.43	3.54
27.1	2.27	-4.79	4.79	2.27	-3.15	4.48
27.7	2.38	-5.81	7.46	2.38	-3.18	6.97
28.3	2.49	-6.60	8.95	2.49	-4.77	5.59
29.0	2.59	-7.52	9.86	2.59	-6.06	9.66
29.6	2.70	-7.57	11.56	2.70	-6.99	7.89
30.2	2.81	-7.35	11.98	2.81	-6.82	9.14
30.8	2.81	-7.17	12.40	2.81	-7.44	10.04
31.4	2.81	-7.95	14.56	2.81	-7.68	10.75

Table A-4 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
32.0	2.81	-8.58	12.55	2.81	-9.69	11.43
32.6	2.81	-8.76	15.27	2.81	-9.76	13.16
33.2	2.81	-8.66	15.59	2.81	-9.02	12.87
33.8	2.81	-8.02	15.01	2.81	-8.80	14.90
34.4	2.81	-7.00	16.09	2.81	-7.09	12.86
35.0	2.81	-7.11	15.14	2.81	-5.57	13.68
35.6	2.81	-7.44	15.16	2.81	-6.04	12.46
36.2	2.66	-8.03	16.06	2.66	-6.47	14.34
36.8	2.51	-7.92	15.57	2.51	-6.00	11.42
37.4	2.36	-6.35	15.68	2.36	-5.46	11.21
38.0	2.21	-5.65	15.16	2.21	-5.43	12.23
38.6	2.06	-4.78	11.51	2.06	-4.27	8.81
39.2	1.90	-4.21	12.28	1.90	-2.48	7.76
39.9	1.75	-4.70	10.40	1.75	-2.75	6.71
40.5	1.59	-3.61	9.56	1.59	-2.45	5.71
41.1	1.43	-2.31	7.23	1.43	-2.58	4.72
41.7	1.27	-1.88	5.60	1.27	-1.80	4.35
42.4	1.11	-1.46	4.24	1.11	-0.85	3.16
43.0	1.00	-0.54	2.64	1.00	0.45	1.09
43.7	1.00	0.31	-2.18	1.00	0.10	-2.29
44.4	1.00	1.49	-2.75	1.00	0.81	-3.75
45.1	1.00	1.73	-3.42	1.00	0.91	-4.97
45.8	1.00	2.03	-5.08	1.00	1.54	-6.36
46.5	1.00	1.57	-7.92	1.00	2.38	-9.20
47.2	1.00	1.57	-12.03	1.00	3.46	-9.14
47.9	1.00	1.65	-11.82	1.00	3.03	-9.04
48.6	1.00	1.16	-10.23	1.00	2.57	-9.62
49.3	1.00	1.70	-8.58	1.00	1.97	-9.56
50.1	1.00	0.73	-6.04	1.00	1.73	-8.91
50.8	1.00	0.35	-5.36	1.00	1.86	-8.19
51.5	1.00	1.54	-2.64	1.00	1.42	-5.70
52.2	1.00	-0.66	-8.24	1.00	1.10	-4.99

Table A-5
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING CM PO MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.00	0.82	-2.25	1.00	-0.70	-0.37
0.7	1.38	0.14	-2.02	1.38	-0.02	-0.05
1.4	1.65	-1.29	0.28	1.65	0.20	1.10
2.0	1.77	-1.94	3.10	1.77	0.66	1.59
2.6	1.90	-2.27	3.64	1.90	0.09	3.84
3.2	1.98	-2.56	5.44	1.98	0.20	4.12
3.8	1.97	-2.81	6.94	1.97	0.98	5.00
4.4	1.97	-4.17	4.98	1.97	-0.15	5.24
5.0	1.92	-3.57	7.55	1.92	-0.67	6.45
5.6	1.68	-3.19	9.19	1.68	-0.94	6.44
6.1	1.41	-2.81	8.99	1.41	-1.37	6.13
7.0	1.20	-3.11	9.67	1.20	-1.54	6.68
7.8	0.64	-3.42	6.94	1.00	-2.19	5.31
8.3	0.45	-3.30	5.30	1.00	-1.73	4.69
8.9	0.54	-2.40	4.43	1.00	-1.38	3.25
9.5	0.74	-0.67	1.13	1.00	-0.26	2.02
10.1	0.96	-0.23	-2.02	1.00	0.31	-3.00
10.7	1.03	0.39	-6.57	1.00	0.68	-5.78
11.4	0.87	1.20	-7.99	1.00	0.81	-7.26
11.7	0.69	1.33	-8.67	1.00	1.53	-9.26
12.1	0.51	0.96	-9.98	1.00	1.22	-11.16
12.8	0.53	1.07	-10.72	1.00	0.93	-9.98
13.6	0.72	1.42	-10.79	1.00	0.74	-8.29
14.4	0.92	1.71	-9.10	1.00	0.44	-6.59
15.1	1.08	0.93	-8.57	1.08	0.12	-4.09
15.8	1.47	-1.24	-2.94	1.47	-0.07	-2.44
16.5	1.68	-2.24	-0.88	1.68	0.01	0.85
17.2	1.80	-2.93	2.69	1.80	-0.59	0.82
17.9	1.97	-3.19	3.48	1.97	-0.64	2.84
18.5	2.12	-3.61	5.20	2.12	-0.89	3.36
19.1	2.22	-3.76	8.18	2.22	-1.24	5.94
19.7	2.22	-3.54	8.65	2.22	-1.62	6.40
20.2	2.14	-3.73	8.54	2.14	-1.70	5.81
20.8	1.99	-3.30	9.92	1.99	-1.27	6.64
21.4	1.74	-3.11	10.63	1.74	-1.97	7.49
22.0	1.45	-3.62	8.35	1.45	-2.65	6.68
22.6	1.31	-2.57	10.37	1.31	-2.76	7.82
23.1	1.22	-2.43	8.56	1.22	-1.78	6.44
23.6	1.16	-1.86	7.92	1.16	-1.45	4.40
24.2	1.10	-1.21	6.72	1.10	-0.89	2.51
24.7	1.03	-0.97	4.55	1.03	-0.10	0.91
25.3	1.00	-0.29	2.66	1.00	-0.02	-1.20
25.9	1.00	0.23	-1.62	1.00	0.36	-2.82
26.4	1.00	0.74	-3.27	1.00	0.44	-3.30
27.1	1.00	1.18	-3.61	1.00	0.61	-4.79
27.8	1.00	1.23	-4.63	1.00	0.42	-4.99
28.5	1.00	0.31	-3.80	1.00	1.28	-3.41

Table A-5 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
29.4	1.00	-0.56	-4.26	1.00	1.10	-1.29
30.2	1.00	-0.45	-1.28	1.00	0.93	-1.52
30.9	1.00	-0.23	-2.72	1.00	0.52	-1.69
31.6	1.00	-0.40	-0.45	1.00	0.58	-0.72
32.3	1.00	-1.16	0.66	1.00	0.64	-0.55
33.0	1.00	-0.43	0.77	1.00	0.64	-0.45
33.6	1.00	0.41	-1.21	1.00	0.56	0.31

Table A-6
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING CM MODIFIED L8 MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	0.88	0.24	-1.70	1.00	0.47	-0.32
0.7	0.84	0.48	-2.47	1.00	-0.05	-0.83
1.3	1.01	0.40	-2.12	1.01	0.17	-2.11
1.9	1.16	0.16	-2.50	1.16	0.55	-2.33
2.6	1.30	0.10	-2.72	1.30	1.01	-3.40
3.2	1.45	0.53	-2.31	1.45	1.04	-2.27
3.9	1.49	0.86	0.21	1.49	1.50	-1.08
4.5	1.46	0.40	-0.15	1.46	1.12	-1.28
5.2	1.40	-0.36	-0.03	1.40	0.79	-0.07
5.8	1.33	-0.82	1.53	1.33	0.28	-0.38
6.5	1.26	-0.61	2.90	1.26	0.38	1.70
7.1	1.20	-0.44	2.26	1.20	-0.24	1.24
7.8	1.17	-0.62	2.57	1.17	-0.10	2.03
8.5	1.18	-0.52	0.54	1.18	0.00	3.14
9.3	1.18	-0.12	0.14	1.18	-0.62	1.73
9.9	1.09	-0.47	-1.20	1.09	-0.29	1.78
10.6	0.94	-0.77	-2.23	1.00	0.33	-0.71
11.3	0.81	-0.71	-1.74	1.00	0.21	-4.36
12.3	0.58	-0.90	-2.93	1.00	1.21	-5.78
13.3	0.54	-0.63	-9.41	1.00	1.36	-6.66
14.0	0.49	0.94	-11.52	1.00	0.82	-8.66
14.7	1.10	0.91	-10.39	1.10	2.49	-5.99
15.5	2.04	-1.74	-5.33	2.04	1.63	-0.95
16.2	1.99	-0.51	-1.10	1.99	0.99	0.40
16.8	1.89	-0.46	0.75	1.89	0.74	0.22
17.5	1.91	-0.98	2.87	1.91	0.09	1.92
18.1	1.93	-1.34	6.19	1.93	-0.07	4.83
18.7	1.92	-1.88	5.70	1.92	-0.65	5.31
19.4	1.93	-1.30	4.52	1.93	-0.29	5.01
20.0	1.93	-0.94	6.73	1.93	-0.32	6.47
20.7	1.87	-1.28	7.65	1.87	-0.86	7.02
21.3	1.71	-1.62	7.95	1.71	-1.92	6.60
21.9	1.66	-1.05	7.25	1.66	-1.80	6.73
22.6	1.71	-1.19	6.12	1.71	-1.30	6.96
23.2	1.80	0.32	5.43	1.80	-1.19	6.73
23.8	1.88	-0.31	4.70	1.88	-1.35	5.96
24.8	1.93	-0.88	5.46	1.93	-0.69	6.62
25.7	1.82	-1.34	4.84	1.82	-1.49	5.27
26.3	1.56	-1.53	5.17	1.56	-1.47	5.52
26.9	1.41	-1.31	4.97	1.41	-1.65	4.11
27.6	1.38	-1.24	4.61	1.38	-1.58	4.67
28.2	1.53	-2.26	6.35	1.53	-0.84	2.94
28.9	1.78	-3.05	6.56	1.78	-0.65	2.00
29.5	1.98	-3.37	4.47	1.98	0.33	3.17
30.1	2.10	-3.18	6.63	2.10	0.38	2.63
30.7	2.25	-3.26	5.23	2.25	0.22	3.28
31.4	2.50	-3.89	6.30	2.50	-0.78	5.52

Table A-6 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
32.0	2.24	-4.43	8.59	2.24	-0.97	6.47
32.6	2.05	-2.97	6.47	2.05	-0.78	6.32
33.2	1.93	-4.89	7.91	1.93	-1.97	7.32
33.9	1.83	-4.21	7.10	1.83	-3.60	7.97
34.5	1.73	-3.73	8.01	1.73	-3.52	8.13
35.1	1.67	-3.75	8.74	1.67	-3.22	7.87
35.7	1.62	-3.03	8.66	1.62	-3.09	9.04
36.3	1.57	-3.78	7.05	1.57	-2.19	7.33
36.9	1.52	-3.54	5.57	1.52	-2.00	7.16
37.6	1.48	-3.35	3.19	1.48	-2.46	5.40
38.2	1.43	-2.72	0.83	1.43	-1.46	5.09
38.8	1.37	-1.99	-0.62	1.37	-0.54	4.64
39.4	1.31	-2.26	-0.15	1.31	-0.31	2.61
40.1	1.27	-1.20	-0.17	1.27	0.14	-0.18
40.7	1.21	-1.99	-1.13	1.21	0.71	-0.14
41.4	1.16	-2.53	-0.96	1.16	1.21	-1.33
43.0	1.03	-1.47	-2.88	1.03	1.52	-1.71
43.3	1.00	-1.34	-3.00	1.00	1.44	-2.62
44.0	0.99	-1.99	-6.05	1.00	0.28	-1.90
44.7	1.00	-1.75	-6.57	1.00	-0.10	-2.70
45.3	1.00	-1.56	-5.75	1.00	0.06	-3.09
46.0	1.00	-1.34	-4.38	1.00	-0.67	-1.35
46.7	1.00	-1.55	-4.39	1.00	0.36	-2.99
47.3	1.00	-1.18	-3.29	1.00	1.09	-1.29
48.0	1.00	-2.29	-1.55	1.00	1.01	-0.88
48.7	1.00	-1.99	0.10	1.00	1.31	0.34
49.4	1.00	-1.64	-0.22	1.00	0.90	-0.27
50.0	1.00	-1.28	0.88	1.00	1.58	-0.42
50.6	1.00	-1.72	-0.18	1.00	2.12	-0.69
51.2	1.00	-1.69	-1.37	1.00	1.85	-2.50
51.9	1.00	-1.68	-1.93	1.00	2.41	-3.29
52.6	1.00	-0.99	0.09	1.00	2.05	-3.54

Table A-7a
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING THREE FM ROR PPM MANEUVERS

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
0.0	0.95	-0.99	-0.85	-0.03	-0.98	-1.63	-0.21
0.6	0.89	-0.18	-1.01	-0.41	1.18	-0.77	0.55
1.2	0.82	0.39	-1.78	-1.36	2.70	-0.61	1.27
1.8	0.76	-0.64	-6.82	-1.09	2.64	-0.55	1.58
2.4	0.70	-1.19	-8.96	-0.87	0.44	-0.63	-1.29
3.0	0.65	-0.72	-7.74	-0.09	-1.84	-1.34	-2.14
3.6	0.60	-0.69	-6.53	-0.27	-4.47	-0.90	-2.21
4.3	0.60	0.04	-4.23	-1.63	-6.07	-0.90	-0.04
4.9	0.60	-0.88	-3.50	-0.79	-6.26	-0.71	-1.62
5.6	0.60	-0.26	-3.14	-0.16	-6.21	-0.14	-2.37
6.3	0.60	-0.45	-2.84	-0.30	-5.90	-0.03	-6.39
7.1	0.60	-0.38	-6.57	-0.64	-5.19	-0.09	-5.68
7.9	0.60	0.39	-7.24	-0.60	-4.30	0.45	-2.79
8.6	0.60	0.57	-5.84	-1.86	-4.72	0.09	-2.13
9.4	0.66	0.34	-4.22	-1.44	-4.10	-0.28	-1.62
10.1	0.74	-0.31	-5.28	-1.44	-3.25	-1.12	-2.13
10.8	0.81	-0.74	-5.40	-1.90	-1.97	-1.19	0.42
11.5	0.87	-1.61	-2.70	-2.38	-0.48	-1.54	-0.72
12.1	0.90	-3.83	-0.34	-4.49	1.44	-2.56	0.90
12.8	1.15	-7.01	0.33	-6.06	6.23	-4.24	1.04
13.4	2.04	-8.86	5.72	-8.30	6.67	-6.95	5.32
14.0	2.83	-13.74	8.21	-12.70	7.58	-10.69	7.21
14.6	3.49	-17.51	13.73	-17.36	12.08	-15.90	11.02
15.2	4.02	-22.29	15.81	-21.16	15.55	-20.40	14.25
15.8	4.29	-24.46	15.83	-21.33	18.59	-22.94	16.05
16.3	4.50	-26.18	20.86	-21.04	20.79	-21.99	23.92
16.9	4.30	-26.15	20.32	-21.50	23.40	-21.24	24.55
17.4	4.20	-24.69	24.85	-20.55	25.07	-20.63	25.99
17.9	3.98	-22.73	25.51	-19.96	24.42	-20.95	28.26
18.5	3.83	-22.29	26.52	-18.67	29.20	-20.82	29.00
19.0	3.58	-20.20	29.94	-18.05	31.40	-18.79	30.91
19.5	3.31	-17.35	30.80	-16.99	32.87	-17.75	30.85
20.0	3.03	-15.97	30.79	-13.82	33.05	-16.69	34.24
20.5	2.76	-14.18	32.15	-11.87	35.45	-15.58	34.92
21.0	2.50	-14.18	29.30	-9.93	32.89	-14.46	32.95
21.5	2.23	-12.90	31.28	-9.25	29.43	-10.99	30.63
22.1	1.95	-11.22	26.15	-6.68	23.89	-9.26	28.34
22.6	1.69	-8.70	22.02	-6.76	18.29	-7.52	25.07
23.1	1.40	-6.61	15.66	-4.53	15.27	-6.68	18.06
23.6	1.14	-5.33	9.66	-4.02	14.63	-3.64	16.14
24.2	1.01	-3.27	8.10	-2.17	11.05	-1.58	14.38
24.8	1.00	-1.16	0.82	-0.41	4.20	-1.36	7.50
25.5	1.00	0.74	-1.86	1.54	-0.46	1.08	7.27
26.2	1.00	0.99	-7.07	2.41	-3.63	2.00	-2.16
26.8	1.00	1.96	-8.03	3.36	-4.96	5.39	-7.34
27.3	1.00	2.91	-7.52	5.12	-8.90	5.53	-8.99
27.9	1.00	2.34	-13.62	5.59	-11.86	6.80	-9.58
28.5	1.00	4.62	-14.38	6.34	-13.80	6.72	-16.72

Table A-7a (Cont'd)

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
29.1	1.00	4.76	-13.66	6.61	-13.46	7.07	-15.87
29.7	1.00	4.05	-11.92	6.13	-11.74	7.59	-17.70
30.4	1.00	3.73	-12.48	5.75	-13.58	6.42	-15.75
31.1	1.00	5.17	-14.18	5.61	-14.49	6.32	-13.05
31.8	1.00	4.10	-13.52	4.89	-14.91	5.00	-12.41
32.5	1.00	3.86	-12.42	4.58	-13.21	4.36	-10.53
33.3	1.00	3.06	-12.56	4.34	-12.03	4.63	-11.11

Table A-7b
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING THREE FM ROR GM MANEUVERS

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
0.0	1.00	-1.72	-1.62	0.70	-0.11	-0.59	1.72
0.6	1.00	-1.74	-0.15	0.21	0.31	-0.45	1.00
1.3	1.00	-2.67	-0.83	-0.01	0.24	-0.31	2.32
1.9	1.00	-1.45	-0.50	-0.17	1.58	-1.43	0.88
2.5	1.00	-1.09	-1.79	0.10	1.95	0.25	0.23
3.1	1.00	-1.18	-4.09	-0.93	2.37	-0.67	0.79
3.8	1.00	-1.88	-2.67	-0.22	2.37	-0.83	2.95
4.5	1.00	-2.67	0.60	-0.20	2.23	0.36	3.23
5.2	1.00	-3.08	-0.16	-0.60	2.96	-0.32	2.57
5.8	1.00	-2.61	0.29	-0.38	3.18	-0.83	1.09
6.5	1.00	-2.88	-1.41	0.29	3.52	-0.05	0.86
7.1	1.00	-2.51	-0.97	-0.11	1.99	0.39	-1.52
7.8	1.00	-2.86	-1.31	0.13	1.82	0.58	-1.68
8.4	1.00	-2.89	-0.36	-0.98	-0.37	0.72	-0.76
9.0	1.00	-3.62	-0.89	-0.19	1.18	-0.26	-1.39
9.7	1.00	-2.91	-0.59	-0.52	3.46	-0.40	-0.03
10.3	1.00	-2.75	-1.83	-0.82	3.32	-0.07	-0.03
10.9	1.00	-2.83	-2.37	-1.36	5.17	-0.37	-0.19
11.6	1.00	-2.29	-3.50	-1.52	5.27	0.34	-1.79
12.2	1.07	-3.45	-2.78	-0.94	5.28	-0.10	-1.93
12.8	1.62	-6.22	0.34	-1.88	6.43	-1.71	-0.51
13.5	2.59	-5.00	4.21	-6.41	7.54	-3.96	-1.62
14.1	3.30	-6.46	6.56	-8.57	9.05	-10.58	6.36
14.6	3.89	-7.65	6.90	-10.68	11.60	-11.33	8.67
15.2	4.34	-12.44	8.27	-15.51	13.39	-14.83	12.14
15.8	4.50	-17.36	12.00	-19.29	14.23	-19.23	16.09
16.4	4.45	-18.93	13.02	-20.92	19.41	-19.09	15.55
16.9	4.36	-19.55	17.20	-22.47	18.85	-19.10	21.52
17.5	4.23	-19.50	17.15	-23.52	22.52	-17.93	20.32
18.0	4.10	-19.16	18.37	-22.59	23.46	-18.82	22.20
18.6	3.90	-19.19	20.38	-23.38	24.44	-19.45	23.19
19.1	3.63	-18.95	22.46	-23.32	25.53	-19.72	25.86
19.5	3.37	-18.79	25.28	-23.77	27.69	-19.06	27.01
20.0	3.10	-15.68	26.62	-19.53	32.41	-15.61	28.33
20.5	2.84	-11.95	25.40	-15.11	31.65	-10.80	26.35
21.0	2.58	-13.71	28.06	-13.57	31.20	-13.25	27.29
21.5	2.30	-12.29	26.15	-14.14	30.66	-12.06	24.68
22.1	2.03	-11.32	24.71	-9.04	24.09	-9.02	24.29
22.6	1.77	-8.58	22.15	-7.17	18.68	-6.42	17.95
23.1	1.47	-6.61	17.61	-3.99	15.47	-3.16	10.20
23.6	1.25	-4.21	8.48	-1.77	9.54	-0.74	6.77
24.2	1.15	-0.31	1.09	-1.17	4.06	1.06	2.79
24.8	1.00	1.18	-9.73	2.60	1.34	1.12	-8.20
26.0	1.00	3.65	-12.33	4.88	-2.63	3.10	-6.64
27.0	1.00	4.66	-12.43	6.04	-7.68	2.99	-6.92
28.0	1.00	4.14	-15.58	6.81	-10.33	3.54	-5.86
28.9	1.00	3.71	-17.39	6.75	-10.18	4.62	-4.17
29.8	1.00	5.12	-20.48	7.37	-11.18	6.77	-5.49

Table A-7b (Cont'd)

Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #3	ΔHR #3
30.4	1.00	5.66	-21.94	8.21	-11.96	5.30	-12.94
31.5	1.00	4.57	-20.33	8.30	-10.67	5.14	-15.18
32.5	1.00	4.82	-19.32	8.41	-10.27	5.38	-16.14
33.5	1.00	3.49	-17.89	8.73	-7.57	5.04	-16.58
34.5	1.00	4.87	-16.38	7.24	-11.97	3.24	-21.79
35.4	1.00	3.60	-17.06	8.30	-8.02	3.88	-20.70
36.3	1.00	4.11	-13.96	7.47	-7.91	3.18	-20.31

Table A-8
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING TWO FM GOR MANEUVERS

		PPM				GM			
Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2
0.0	1.10	0.26	-1.84	-0.35	1.26	0.89	1.96	-0.38	-0.44
0.6	1.23	0.23	-1.52	0.09	0.42	1.27	1.17	-0.92	0.50
1.3	1.30	0.53	-0.85	-0.81	2.86	2.22	3.08	-1.19	0.72
1.9	1.36	0.18	-0.38	-0.85	0.21	1.29	2.00	-1.57	3.22
2.6	1.41	0.26	-0.04	-1.65	3.47	2.54	0.83	-0.71	3.11
3.2	1.46	0.58	-1.80	-2.11	3.37	3.01	1.88	-1.22	3.07
3.9	1.52	0.56	-0.34	-2.03	3.14	2.79	0.99	-1.41	3.55
4.6	1.58	0.26	-0.57	-2.44	4.18	2.76	3.62	-2.09	2.27
5.2	1.64	0.21	0.97	-3.04	5.35	2.52	3.91	-1.84	3.88
5.8	1.69	-0.50	-0.63	-3.67	6.30	2.16	3.93	-2.74	3.05
6.5	1.75	-0.88	0.13	-2.85	7.71	2.03	6.61	-3.36	5.03
7.1	1.80	-1.31	1.62	-2.22	8.70	2.11	6.18	-3.34	6.67
7.7	1.85	-1.36	1.01	-3.25	8.01	2.95	7.13	-3.15	7.05
8.3	1.90	-1.23	2.08	-3.17	7.86	3.11	4.68	-3.36	7.72
9.0	1.95	-1.53	2.33	-3.01	7.22	2.52	4.31	-4.15	8.14
9.6	2.01	-1.97	2.48	-2.95	6.76	1.57	7.41	-4.15	8.90
10.2	2.06	-3.05	3.54	-2.79	7.32	1.54	6.03	-4.15	10.68
10.8	2.11	-3.24	5.20	-4.09	8.06	1.95	6.64	-4.28	8.97
11.4	2.17	-3.32	5.37	-5.34	9.18	1.54	6.98	-4.72	10.65
12.1	2.23	-3.64	6.61	-5.53	10.88	0.92	7.36	-4.12	10.28
12.7	2.28	-3.17	6.22	-4.69	10.90	1.08	9.42	-4.77	11.43
13.3	2.34	-2.71	5.22	-5.04	10.55	0.73	8.50	-6.02	13.68
13.9	2.39	-3.37	5.92	-4.88	10.01	0.59	10.72	-5.97	10.48
14.5	2.44	-3.19	7.88	-5.42	12.68	-0.31	10.15	-6.35	14.24
15.1	2.50	-3.48	5.67	-5.86	11.22	1.27	10.32	-6.87	13.50
15.7	2.55	-3.70	7.40	-5.59	13.38	0.78	12.08	-7.08	13.39
16.3	2.60	-3.32	9.20	-5.69	12.30	0.13	10.48	-8.46	15.33
16.9	2.65	-3.24	9.39	-6.48	14.19	-0.14	10.98	-7.73	16.49
17.5	2.70	-3.86	10.05	-6.59	14.44	-0.09	11.55	-7.19	17.04
18.1	2.75	-4.00	8.45	-6.64	14.94	-0.17	12.80	-8.52	18.87
18.7	2.80	-5.14	10.74	-7.46	14.59	-0.38	12.51	-10.06	17.20
19.3	2.86	-5.05	10.96	-7.89	16.51	-1.31	12.26	-9.74	17.44
19.9	2.91	-4.27	11.03	-9.22	17.12	-1.34	15.14	-10.34	19.62
20.5	2.96	-4.57	11.03	-8.16	19.61	-3.34	13.81	-9.63	19.18
21.2	3.01	-5.14	12.07	-7.05	18.21	-2.94	14.87	-9.01	17.26
21.7	3.06	-4.84	11.45	-8.54	17.35	-2.80	13.24	-8.68	20.03
22.3	3.10	-4.27	11.14	-9.38	20.35	-4.59	15.04	-9.52	19.36
22.9	3.16	-4.95	12.56	-9.63	18.64	-6.36	17.24	-10.04	21.19
23.5	3.21	-5.27	14.71	-8.84	20.19	-5.86	17.85	-10.44	20.54
24.1	3.26	-5.49	13.02	-9.18	20.28	-5.08	16.71	-11.88	21.50
24.7	3.32	-5.95	15.59	-8.16	23.52	-4.89	18.09	-11.18	20.56
25.3	3.36	-6.30	14.40	-8.16	21.16	-6.30	18.40	-11.91	22.51
25.8	3.41	-6.41	16.53	-8.54	21.79	-7.33	18.50	-12.69	22.68
26.4	3.47	-5.11	15.57	-8.87	20.37	-7.19	20.64	-12.80	23.26
27.0	3.51	-5.00	15.56	-8.81	20.98	-5.51	18.93	-12.58	22.69
27.6	3.56	-6.36	17.64	-10.20	19.92	-5.19	21.64	-12.08	24.87
28.1	3.61	-6.36	15.79	-9.68	23.23	-7.20	20.95	-12.84	25.16

Table A-8 (Cont'd)

		PPM				GM			
Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2
28.7	3.65	-6.95	19.28	-8.31	23.60	-8.14	19.97	-13.51	26.08
29.2	3.70	-7.20	19.07	-8.38	24.92	-7.55	20.52	-13.81	28.93
29.8	3.75	-6.33	18.57	-10.52	24.72	-7.30	22.55	-13.39	28.41
30.3	3.80	-5.46	19.52	-12.75	26.32	-8.99	23.68	-14.01	30.54
30.9	3.85	-6.82	17.97	-13.56	26.37	-10.10	23.37	-13.59	28.03
31.4	3.89	-6.57	17.12	-14.10	27.90	-9.45	24.22	-13.54	28.74
31.9	3.95	-6.33	18.51	-13.40	29.57	-8.31	23.84	-12.99	31.86
32.5	4.00	-6.85	17.00	-10.85	30.48	-8.52	24.41	-12.48	29.53
33.0	4.04	-6.11	17.74	-10.33	29.90	-9.39	26.13	-14.78	32.83
33.6	4.09	-7.25	19.70	-11.72	29.03	-9.07	28.26	-12.75	32.14
34.1	4.14	-9.13	18.89	-12.29	31.00	-8.01	27.30	-12.78	31.50
34.6	4.18	-8.80	21.00	-11.55	31.16	-7.76	27.87	-12.26	33.31
35.1	4.23	-8.85	20.86	-12.74	31.69	-8.44	27.07	-13.50	33.54
35.6	4.35	-10.86	21.83	-13.29	33.21	-9.00	28.15	-15.36	34.05
36.1	4.45	-10.15	22.20	-12.78	34.38	-10.34	28.00	-15.99	37.23
36.7	4.50	-9.29	19.70	-11.93	34.12	-11.05	29.52	-13.41	36.51
37.2	4.50	-7.72	23.34	-10.06	35.35	-9.77	30.75	-13.40	34.32
37.7	4.50	-7.31	22.47	-9.00	34.20	-8.93	29.81	-12.58	36.31
38.2	4.50	-8.36	20.98	-10.96	36.30	-9.47	31.11	-14.43	37.13
38.7	4.50	-9.39	22.86	-10.32	35.41	-9.20	31.24	-14.48	37.96
39.2	4.50	-7.35	22.98	-11.16	37.75	-9.38	29.23	-13.05	38.03
39.7	4.50	-6.80	22.23	-9.44	36.82	-10.05	28.46	-11.80	38.21
40.2	4.40	-6.11	21.96	-9.31	36.53	-11.53	30.66	-11.99	37.81
40.7	4.30	-5.98	24.44	-11.31	35.50	-12.00	31.84	-13.14	38.08
41.2	4.14	-5.06	23.87	-10.98	37.20	-10.64	30.41	-12.51	36.69
41.8	4.04	-5.25	26.67	-9.25	35.57	-10.88	30.86	-12.42	38.71
42.2	3.94	-3.83	22.74	-9.49	36.30	-12.17	33.25	-13.18	38.15
42.7	3.86	-3.21	22.15	-8.90	34.31	-10.35	34.56	-11.83	38.42
43.3	3.77	-4.19	23.13	-11.33	36.25	-9.59	34.59	-12.07	38.28
43.8	3.68	-3.39	21.80	-11.63	35.08	-10.87	35.16	-12.02	40.09
44.3	3.59	-3.67	21.27	-10.98	35.91	-10.05	34.73	-10.25	39.54
44.8	3.50	-6.16	20.70	-9.21	35.71	-9.57	36.34	-10.39	36.89
45.2	3.42	-5.99	21.00	-9.60	36.42	-7.96	35.98	-10.85	38.71
45.8	3.33	-6.30	20.50	-9.75	36.83	-7.66	35.75	-11.88	38.62
46.3	3.24	-6.53	23.00	-9.17	36.13	-7.20	35.29	-11.92	36.74
46.7	3.15	-6.10	21.10	-6.70	35.40	-5.59	34.35	-10.72	38.40
47.3	3.06	-4.17	21.74	-6.72	36.27	-2.45	30.71	-9.01	37.74
47.8	2.98	-2.90	19.87	-6.56	33.93	-1.58	30.47	-7.68	36.05
48.3	2.89	-2.85	20.79	-6.72	36.89	-1.47	29.64	-6.89	35.61
48.8	2.81	-3.62	18.44	-5.29	34.40	-2.07	30.34	-6.27	33.43
49.3	2.72	-3.08	20.15	-4.01	37.46	-2.01	29.15	-6.51	35.54
49.8	2.64	-2.75	20.63	-3.03	33.27	-0.69	29.40	-6.27	34.60
50.3	2.55	-2.01	20.71	-2.97	31.75	-1.09	27.23	-4.26	35.13
50.8	2.46	-2.42	19.45	-2.74	33.94	-0.47	27.26	-3.50	33.68
51.3	2.37	-0.74	17.35	-2.25	32.69	-0.78	27.44	-4.84	34.28
51.8	2.29	0.00	16.30	-2.81	30.35	-1.69	27.03	-5.15	32.91
52.3	2.20	0.48	14.54	-2.33	28.59	-1.40	24.35	-4.77	31.95
52.8	2.13	-0.50	15.17	-3.11	27.04	-0.20	26.54	-4.11	32.38
53.4	2.04	-0.98	14.20	-1.71	26.19	0.25	25.21	-5.16	31.30

Table A-8 (Cont'd)

		PPM				GM			
Time (sec)	Gz	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2	ΔSBP #1	ΔHR #1	ΔSBP #2	ΔHR #2
53.9	1.95	0.23	13.22	-0.81	24.22	-0.78	25.79	-5.70	29.77
54.4	1.84	1.40	11.76	-0.59	22.53	-0.55	25.81	-5.30	31.50
54.9	1.76	1.73	10.50	-1.30	23.15	0.64	23.62	-4.96	30.76
55.4	1.67	1.82	10.66	-0.24	23.03	1.95	24.29	-3.04	30.77
55.9	1.58	1.00	7.75	1.17	20.23	2.24	22.18	-1.48	28.98
56.4	1.48	1.86	5.40	0.79	18.92	2.90	20.82	-1.94	27.35
57.0	1.39	2.85	3.96	2.08	17.17	3.17	18.74	-0.71	24.00
57.5	1.26	3.29	3.25	2.62	16.63	3.25	15.08	0.37	23.97
58.1	1.12	3.50	-0.78	2.85	14.17	3.32	12.38	0.72	21.35
58.6	1.04	3.25	-4.31	4.38	8.48	4.85	9.57	1.36	18.44
59.3	1.00	3.93	-6.09	6.09	5.86	6.72	2.34	2.44	17.03
59.9	1.00	3.62	-7.02	5.56	2.02	7.02	-0.05	3.93	10.63
60.5	1.00	3.79	-5.49	5.86	-2.17	7.16	-1.10	3.88	8.05
61.1	1.00	5.11	-7.00	7.11	-5.42	8.05	-2.72	4.56	5.40
61.8	1.00	4.47	-7.32	6.68	-3.11	7.81	-9.58	5.10	3.07
62.5	1.00	3.52	-5.06	6.70	-1.85	8.76	-9.32	4.59	-2.32
63.1	1.00	3.19	-4.42	6.90	-1.21	8.30	-9.50	6.10	-0.26
63.8	1.00	2.05	-3.00	6.03	-1.83	7.82	-8.23	5.37	1.67
64.4	1.00	2.70	-6.51	5.51	-0.48	6.13	-4.24	5.48	0.90
65.1	1.00	2.89	-9.67	5.37	-2.27	6.48	-3.45	4.48	0.96
65.8	1.00	3.35	-10.03	5.76	-1.22	6.12	-4.05	4.12	1.88
66.4	1.00	3.57	-12.01	5.73	-2.08	4.96	-4.54	3.93	3.78
67.1	1.00	2.73	-8.59	5.48	0.76	5.64	-4.00	4.33	4.65
67.7	1.00	3.02	-7.92	6.03	1.91	4.44	-2.27	4.11	7.58

Table A-9
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING FM LHR MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.00	-0.41	2.48	1.00	-0.70	-0.16
0.6	1.15	-1.06	2.38	1.15	-0.78	1.92
1.2	1.35	-1.85	3.70	1.35	-0.81	0.45
1.9	1.45	-1.17	3.44	1.45	-0.37	0.55
2.5	1.67	-1.58	2.70	1.67	-0.21	1.46
3.1	1.78	-0.66	2.72	1.78	-1.65	2.72
3.8	1.89	-1.91	3.53	1.89	-1.87	5.86
4.4	2.00	-2.64	5.24	2.00	-2.27	5.62
5.1	2.10	-3.67	4.68	2.10	-2.25	7.33
5.7	2.21	-4.94	8.14	2.21	-3.39	8.67
6.3	2.32	-4.75	8.63	2.32	-3.06	8.05
6.9	2.43	-5.84	7.74	2.43	-4.52	9.97
7.5	2.53	-7.66	12.37	2.53	-3.63	12.18
8.0	2.63	-8.61	13.78	2.63	-5.04	11.10
8.6	2.71	-8.93	14.64	2.71	-5.47	12.55
9.2	2.82	-8.36	18.54	2.82	-7.45	13.77
9.7	2.90	-8.99	16.56	2.90	-8.02	15.27
10.3	3.00	-8.28	18.22	3.00	-6.72	15.44
10.8	3.00	-7.93	21.19	3.00	-7.65	16.45
11.3	3.00	-7.33	20.93	3.00	-9.60	16.99
12.2	2.84	-4.55	19.66	2.84	-9.84	18.05
13.6	2.65	-4.11	19.52	2.65	-9.57	18.83
14.6	2.47	-3.51	19.76	2.47	-8.84	19.43
15.1	2.29	-4.94	18.34	2.29	-8.73	18.22
15.6	2.10	-3.88	19.09	2.10	-7.37	17.46
16.2	1.93	-2.15	17.13	1.93	-5.18	17.24
16.7	1.66	-1.50	13.99	1.66	-4.88	15.03
17.2	1.38	-1.28	11.81	1.38	-3.90	14.41
17.8	1.18	-0.03	7.89	1.18	-3.19	8.86
18.6	0.98	1.50	2.94	1.00	-0.95	5.78
19.4	0.76	1.78	1.28	1.00	-0.08	-0.27
19.9	0.56	1.86	-2.10	1.00	0.90	-4.79
20.5	0.35	4.13	-2.60	1.00	-0.24	-10.31
21.0	0.15	3.17	-6.54	1.00	1.88	-9.63
21.6	-0.05	2.20	-13.44	1.00	2.13	-8.95
22.2	-0.23	3.26	-17.40	1.00	1.56	-7.41
22.9	-0.52	3.14	-20.35	1.00	0.60	-5.48
23.6	-0.75	3.64	-21.00	1.00	0.52	-3.38
24.3	-1.00	1.54	-28.21	1.00	1.71	-2.65
25.2	-0.75	3.90	-24.19	1.00	1.25	-4.86
26.0	-0.25	2.70	-13.62	1.00	0.67	-3.73
26.7	0.67	1.86	-13.29	1.00	0.39	-4.33
27.4	1.24	2.62	-14.26	1.24	0.52	-4.56
28.0	1.75	1.15	-9.31	1.75	-0.14	-4.63
28.7	2.21	-1.58	-4.17	2.21	-2.18	-4.31
29.3	2.61	-3.88	1.74	2.61	-2.25	0.41
29.9	3.00	-4.92	6.80	3.00	-5.15	2.24

Table A-9 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
30.5	3.33	-6.72	11.33	3.33	-8.09	7.61
31.1	3.64	-8.80	11.87	3.64	-10.44	10.37
31.7	3.96	-10.59	15.82	3.96	-11.92	13.74
32.2	4.24	-14.68	23.49	4.24	-15.56	16.87
32.8	4.43	-18.34	17.03	4.43	-18.45	17.80
33.3	4.50	-17.34	22.03	4.50	-20.77	20.93
33.9	4.45	-18.07	24.48	4.45	-21.43	24.88
34.4	4.29	-17.56	28.79	4.29	-19.26	25.62
34.9	4.07	-17.59	28.35	4.07	-18.47	24.35
35.4	3.84	-16.40	31.44	3.84	-17.60	26.78
35.9	3.62	-15.75	31.58	3.62	-16.82	26.05
36.4	3.46	-14.03	33.33	3.46	-13.20	26.15
36.9	3.35	-12.12	34.59	3.35	-10.03	25.66
37.4	3.27	-11.24	35.52	3.27	-10.14	25.90
37.8	3.20	-9.67	33.69	3.20	-9.03	24.18
38.3	3.11	-9.43	36.22	3.11	-10.51	26.69
38.8	3.02	-8.93	34.82	3.02	-9.18	23.63
39.3	2.95	-9.15	36.27	2.95	-7.05	22.48
39.7	2.86	-7.64	38.98	2.86	-5.42	21.48
40.2	2.77	-7.25	37.45	2.77	-6.40	22.93
40.6	2.71	-6.00	35.64	2.71	-5.44	21.09
41.1	2.65	-6.49	36.28	2.65	-5.22	22.84
41.5	2.60	-6.73	36.16	2.60	-4.99	23.61
42.0	2.54	-6.57	35.07	2.54	-4.50	23.46
42.4	2.48	-7.56	34.57	2.48	-3.60	24.38
42.9	2.42	-5.11	34.52	2.42	-3.50	22.15
43.3	2.36	-3.37	32.60	2.36	-1.64	21.20
43.8	2.31	-2.68	32.29	2.31	-1.81	22.59
44.3	2.25	-1.99	29.72	2.25	-1.16	21.86
44.7	2.20	-1.30	29.82	2.20	-2.54	18.90
45.2	2.14	-0.61	27.47	2.14	0.22	20.82
45.7	2.09	0.08	26.16	2.09	-0.18	18.74
46.2	2.00	0.77	23.11	2.00	2.28	17.13
46.6	1.91	1.46	20.70	1.91	1.99	14.73
47.6	1.85	2.16	19.82	1.85	1.55	13.06
48.6	1.80	2.85	18.83	1.80	1.58	9.87
49.0	1.73	3.54	18.89	1.73	2.99	9.18
49.5	1.67	4.23	18.82	1.67	2.80	9.00
50.0	1.58	4.92	18.74	1.58	2.38	8.00
50.5	1.47	5.61	16.72	1.47	1.92	6.93
51.0	1.41	6.30	15.36	1.41	2.91	4.87
52.0	1.35	6.99	9.99	1.35	3.18	1.77
53.0	1.29	7.68	7.73	1.29	4.38	1.56
53.5	1.22	8.37	1.05	1.22	3.45	4.44
54.0	1.10	9.06	0.80	1.10	2.18	2.88
54.5	1.00	9.75	1.88	1.00	2.42	2.44
55.0	1.00	10.44	2.99	1.00	2.50	1.03
55.5	1.00	4.01	0.53	1.00	2.50	0.79
56.1	1.00	3.71	1.54	1.00	2.83	0.80

Table A-9 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
56.6	1.00	2.85	-1.05	1.00	1.88	-0.69
57.1	1.00	2.92	-1.46	1.00	0.77	-3.57
57.7	1.00	2.54	0.31	1.00	2.15	-2.46
58.2	1.00	0.50	-1.32	1.00	1.44	-2.06
58.7	1.00	2.17	-0.96	1.00	1.04	-1.38
59.3	1.00	0.57	-1.53	1.00	0.87	-0.89

Table A-10
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING FM LHG MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.00	-0.89	-2.09	1.00	0.39	-2.03
0.3	1.06	-1.27	-1.98	1.06	-0.29	-1.81
0.6	1.12	-1.03	-0.31	1.12	-0.01	-1.02
1.2	1.18	-0.62	1.23	1.18	0.09	0.50
1.8	1.23	-1.65	0.59	1.23	-0.80	0.37
2.4	1.29	-1.65	0.42	1.29	-1.40	1.66
3.0	1.34	-2.90	1.45	1.34	-1.86	1.64
3.7	1.41	-3.79	-0.26	1.41	-1.89	1.80
4.4	1.48	-3.44	0.36	1.48	-1.48	2.94
5.1	1.54	-3.63	1.32	1.54	-2.08	2.59
5.8	1.60	-4.36	3.15	1.60	-2.00	4.01
6.4	1.66	-5.01	2.38	1.66	-1.37	4.05
7.0	1.72	-4.88	2.10	1.72	-2.05	3.79
7.6	1.78	-4.85	5.23	1.78	-3.03	6.53
8.2	1.83	-4.88	5.88	1.83	-3.05	8.19
8.8	1.89	-5.39	6.71	1.89	-2.51	7.29
9.4	2.00	-5.83	8.64	2.00	-2.54	7.52
10.0	2.00	-5.58	7.60	2.00	-3.89	9.67
10.6	2.00	-5.59	6.99	2.00	-4.41	9.04
11.2	2.00	-5.47	6.87	2.00	-4.44	10.51
11.8	2.00	-5.31	6.87	2.00	-5.19	11.10
12.4	2.00	-5.83	7.26	2.00	-4.26	11.04
13.0	2.00	-6.52	6.77	2.00	-4.44	11.44
13.6	1.89	-5.85	8.35	1.89	-3.00	11.43
14.2	1.78	-5.01	6.75	1.78	-2.76	11.16
14.7	1.67	-4.63	7.54	1.67	-3.71	10.30
15.3	1.56	-4.24	6.18	1.56	-3.57	10.28
15.9	1.47	-4.78	6.69	1.47	-3.38	10.46
16.8	1.31	-4.45	6.50	1.31	-2.46	8.70
17.7	1.15	-3.93	7.06	1.15	-1.63	7.99
18.3	1.06	-3.94	5.53	1.06	-1.42	4.51
18.9	0.96	-2.17	2.30	1.00	-0.80	0.72
19.4	0.85	-1.38	0.34	1.00	0.56	-0.35
20.0	0.75	-0.80	-3.73	1.00	0.23	-6.30
20.6	0.65	-0.11	-5.78	1.00	0.34	-10.04
21.6	0.49	-0.36	-8.97	1.00	1.04	-8.68
22.5	0.32	-0.40	-10.32	1.00	1.41	-6.48
23.2	0.22	-0.24	-13.00	1.00	1.66	-5.76
23.8	0.10	0.49	-15.12	1.00	2.34	-4.50
24.5	-0.03	0.52	-16.40	1.00	1.34	-4.20
25.2	-0.20	-0.91	-18.35	1.00	0.96	-3.02
26.0	-0.32	-0.93	-19.61	1.00	0.58	-2.23
26.8	-0.47	0.10	-22.94	1.00	0.88	-0.97
27.7	-0.66	-1.32	-21.95	1.00	1.04	0.11
28.8	-0.83	-1.69	-21.51	1.00	0.23	-2.80
29.9	-1.00	-1.47	-23.24	1.00	0.45	-1.27
30.7	-1.00	-2.73	-25.78	1.00	0.36	-2.49

Table A-10 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
31.4	-1.00	-2.27	-25.42	1.00	0.32	-3.71
32.2	-1.00	-2.79	-24.28	1.00	0.15	-2.39
33.0	-1.00	-2.76	-23.31	1.00	-0.80	-1.48
33.8	-0.74	-3.07	-22.16	1.00	-0.40	-1.18
34.5	-0.65	-3.36	-20.53	1.00	-0.68	-0.99
35.2	-0.51	-2.60	-18.30	1.00	-0.48	0.14
35.9	-0.42	-2.47	-16.59	1.00	-0.38	0.15
36.6	-0.32	-2.22	-12.00	1.00	-0.39	-1.73
37.3	-0.15	-2.28	-9.85	1.00	0.34	0.15
38.2	-0.04	-2.38	-5.05	1.00	-0.49	-0.77
39.1	0.06	-2.99	-3.44	1.00	-0.75	-2.29
39.8	0.17	-3.14	-2.48	1.00	-0.04	-1.45
40.7	0.31	-3.40	-1.11	1.00	-0.59	-0.29
41.6	0.41	-3.71	-0.82	1.00	-0.13	-0.30
42.2	0.54	-3.96	1.54	1.00	-0.69	-0.49
42.8	0.68	-5.23	3.39	1.00	0.92	-0.62
43.4	0.78	-4.99	4.52	1.00	-0.75	-0.98
44.0	0.88	-4.44	5.25	1.00	0.39	-0.18
44.6	0.97	-4.17	5.84	1.00	-0.42	0.55
45.2	1.07	-4.20	4.81	1.07	0.15	2.19
45.8	1.16	-4.59	5.59	1.16	0.24	1.67
46.4	1.25	-4.54	6.36	1.25	0.81	0.14
47.0	1.34	-5.42	8.60	1.34	0.83	0.33
47.8	1.43	-5.45	8.72	1.43	-0.10	1.96
48.6	1.53	-6.62	10.35	1.53	-0.12	3.36
49.2	1.67	-6.78	9.65	1.67	-0.21	3.58
49.8	1.78	-5.18	14.40	1.78	-0.56	4.57
50.6	1.88	-7.89	13.92	1.88	-1.35	5.90
51.4	1.98	-7.43	15.69	1.98	-1.73	7.64
51.9	2.11	-8.82	15.77	2.11	-2.00	8.68
52.5	2.23	-8.94	17.59	2.23	-2.02	10.22
53.0	2.32	-8.96	20.08	2.32	-3.88	11.60
53.5	2.41	-9.16	18.72	2.41	-5.55	13.67
54.1	2.51	-9.77	21.14	2.51	-4.65	12.87
54.6	2.59	-9.54	22.04	2.59	-5.44	16.18
55.1	2.67	-9.71	23.73	2.67	-4.52	14.83
55.6	2.75	-10.60	22.14	2.75	-5.13	16.52
56.2	2.84	-10.91	23.94	2.84	-6.96	17.16
56.7	2.92	-11.81	26.78	2.92	-9.24	16.21
57.2	3.01	-12.01	24.38	3.01	-9.10	19.62
57.7	3.08	-11.15	25.93	3.08	-9.43	21.34
58.2	3.17	-10.67	28.20	3.17	-11.17	21.79
58.7	3.25	-10.13	26.45	3.25	-12.95	22.17
59.5	3.33	-10.12	26.74	3.33	-12.85	24.49
60.3	3.42	-12.94	28.90	3.42	-11.03	24.60
60.7	3.54	-12.89	29.29	3.54	-10.68	24.73
61.3	3.66	-12.37	29.34	3.66	-11.96	27.04
61.7	3.73	-12.22	30.25	3.73	-12.82	26.57
62.2	3.81	-12.07	30.97	3.81	-12.37	28.48

Table A-10 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
62.7	3.89	-10.79	30.10	3.89	-13.53	28.95
63.3	3.97	-11.86	31.47	3.97	-11.34	30.79
63.7	4.05	-12.17	32.79	4.05	-9.97	29.66
64.5	4.13	-12.85	30.23	4.13	-11.64	29.80
64.7	4.22	-11.80	32.86	4.22	-13.87	31.55
65.2	4.34	-12.78	31.75	4.34	-13.10	31.78
65.7	4.39	-14.96	33.29	4.39	-12.52	33.99
66.2	4.49	-15.28	35.70	4.49	-12.60	33.62
66.7	4.49	-13.66	34.61	4.49	-14.01	33.51
67.2	4.49	-13.97	35.43	4.49	-13.64	35.53
67.7	4.49	-14.67	34.66	4.49	-13.96	35.98
68.2	4.49	-14.26	37.85	4.49	-14.72	36.27
68.7	4.49	-13.69	37.75	4.49	-10.80	35.28
69.2	4.49	-12.31	35.97	4.49	-10.87	36.12
69.6	4.49	-11.08	35.65	4.49	-11.77	37.10
70.1	4.37	-11.39	35.47	4.37	-12.17	37.81
70.6	4.11	-10.98	40.35	4.11	-11.40	38.81
71.1	4.06	-9.85	34.84	4.06	-8.92	37.32
71.5	3.95	-8.32	33.90	3.95	-9.32	38.34
72.0	3.84	-8.13	36.30	3.84	-9.36	38.04
72.5	3.71	-8.62	35.00	3.71	-8.94	39.33
73.0	3.59	-10.74	36.25	3.59	-8.49	36.39
73.5	3.48	-9.76	35.13	3.48	-8.67	37.73
73.9	3.36	-9.44	35.23	3.36	-9.05	37.95
74.4	3.25	-8.81	36.41	3.25	-6.16	38.22
74.9	3.14	-10.59	34.82	3.14	-6.23	38.31
75.4	3.03	-11.12	35.46	3.03	-7.30	36.06
75.8	2.91	-11.31	39.57	2.91	-9.21	34.78
76.3	2.81	-8.32	37.29	2.81	-8.13	37.08
76.8	2.70	-8.19	37.13	2.70	-6.64	36.04
77.3	2.59	-8.19	35.90	2.59	-6.91	36.00
77.8	2.48	-9.07	36.78	2.48	-5.12	36.26
78.2	2.37	-8.32	36.88	2.37	-3.95	35.86
78.7	2.26	-5.55	37.75	2.26	-4.45	33.01
79.2	2.15	-4.02	33.89	2.15	-4.17	35.17
79.7	2.03	-2.73	30.16	2.03	-2.70	31.67
80.2	1.92	-1.66	25.64	1.92	-1.32	31.81
80.7	1.81	-0.90	21.70	1.81	0.18	28.59
81.2	1.70	-0.86	18.18	1.70	-0.27	28.32
81.7	1.58	-0.52	18.67	1.58	0.01	23.34
82.4	1.39	1.32	18.87	1.39	1.44	17.72
83.2	1.22	1.52	17.71	1.22	2.24	15.41
83.7	1.10	1.81	16.02	1.10	2.56	12.98
84.2	1.00	2.94	11.66	1.00	4.41	10.27
84.8	1.00	2.68	10.35	1.00	4.54	5.63
85.3	1.00	3.41	8.89	1.00	5.14	7.72
85.8	1.00	3.76	8.41	1.00	5.22	2.89
86.4	1.00	3.90	2.53	1.00	5.44	3.07
86.9	1.00	4.09	4.73	1.00	4.38	1.12

Table A-10 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
87.5	1.00	3.52	4.01	1.00	4.13	1.70
88.0	1.00	3.60	5.39	1.00	5.00	1.83
88.6	1.00	3.46	1.93	1.00	5.66	1.22
89.1	1.00	3.44	-0.50	1.00	5.41	-1.22
89.7	1.00	3.60	-1.98	1.00	5.49	0.39
90.2	1.00	3.98	-1.44	1.00	4.73	-0.27
90.8	1.00	3.27	-0.63	1.00	4.40	-0.13
91.3	1.00	2.81	-2.04	1.00	3.88	0.45

Table A-11
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING FM PO MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.0	1.12	0.21	-0.11	1.12	-1.17	0.33
0.6	1.41	0.05	-0.60	1.41	-1.25	0.60
1.2	1.70	-0.60	1.03	1.70	-1.36	2.22
1.7	1.97	-2.56	1.67	1.97	-3.20	1.68
2.3	2.25	-3.51	3.03	2.25	-3.26	0.77
3.1	2.50	-3.78	5.54	2.50	-6.48	1.31
4.1	2.50	-5.41	5.25	2.50	-6.84	5.34
4.9	2.11	-6.03	6.23	2.11	-9.01	5.70
5.4	1.85	-7.41	10.89	1.85	-8.25	8.09
6.0	1.59	-7.98	10.74	1.59	-8.19	8.06
6.5	1.34	-6.60	13.02	1.34	-8.06	10.02
7.0	1.09	-6.87	13.26	1.09	-7.62	10.64
7.5	0.84	-6.41	13.35	1.00	-5.21	11.03
8.0	0.59	-6.49	11.91	1.00	-6.67	11.69
8.5	0.34	-5.49	9.06	1.00	-6.11	11.17
9.0	0.07	-5.68	1.45	1.00	-4.75	8.02
9.6	-0.21	-4.52	-4.22	1.00	-2.47	4.69
10.1	-0.51	-3.84	-10.95	1.00	-2.82	-5.32
10.7	-0.80	-3.53	-15.93	1.00	-1.17	-6.86
11.3	-1.00	-3.36	-15.51	1.00	-0.90	-12.40
12.1	-1.00	-2.52	-19.35	1.00	-0.49	-17.44
13.3	-0.30	-0.77	-17.99	1.00	-0.05	-15.33
14.4	0.33	-1.81	-22.64	1.00	-0.76	-13.43
15.5	0.93	-1.31	-20.79	1.00	-1.19	-10.61
16.2	1.00	-1.45	-18.76	1.00	-1.11	-8.41
17.3	0.48	-0.47	-13.65	1.00	-1.25	-7.57
18.2	0.04	-0.28	-11.17	1.00	-1.52	-5.61
19.0	-0.37	-1.12	-9.15	1.00	-1.98	-4.44
19.7	-0.76	-2.86	-8.98	1.00	-2.01	-2.72
20.1	-0.96	-3.78	-13.81	1.00	-1.71	-3.62
20.5	-1.00	-4.16	-17.82	1.00	-1.27	-5.02
21.2	-1.00	-4.02	-22.01	1.00	-0.79	-7.45
21.9	-0.65	-3.42	-21.52	1.00	-0.33	-9.03
22.6	-0.28	-2.42	-13.43	1.00	-0.60	-7.89
23.3	0.08	-5.38	-15.05	1.00	-0.87	-6.96
24.0	0.42	-5.57	-5.55	1.00	-0.37	-5.54
24.4	0.66	-7.25	-8.13	1.00	-0.20	-3.35
25.2	1.07	-7.06	-1.94	1.07	-0.70	-2.32
25.9	1.42	-7.71	0.29	1.42	-1.39	-1.32
26.5	1.74	-8.38	6.09	1.74	-2.96	-1.19
27.1	2.04	-10.28	7.95	2.04	-4.10	0.43
27.9	2.48	-11.31	10.04	2.48	-6.54	1.88
28.8	2.92	-12.61	9.42	2.92	-10.12	5.07
29.3	3.20	-14.10	12.34	3.20	-12.04	7.47
29.8	3.47	-16.66	15.42	3.47	-14.22	10.40
30.4	3.50	-16.99	15.29	3.50	-14.71	11.48
30.9	3.50	-16.48	17.26	3.50	-15.40	13.46

Table A-11 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
31.4	3.24	-15.30	21.39	3.24	-15.86	15.08
31.9	3.00	-14.01	20.26	3.00	-13.75	16.57
32.4	2.75	-13.87	21.40	2.75	-12.24	17.88
32.9	2.49	-13.23	19.57	2.49	-10.20	16.56
33.4	2.24	-12.54	20.46	2.24	-7.68	16.98
33.9	2.00	-11.40	18.66	2.00	-7.39	15.74
34.4	1.75	-10.85	19.87	1.75	-6.34	13.31
34.9	1.50	-9.90	18.38	1.50	-5.60	10.16
35.4	1.25	-9.31	15.41	1.25	-4.10	6.17
35.9	1.00	-7.22	11.76	1.00	-3.15	-0.28
36.4	1.00	-5.60	3.34	1.00	-0.22	-5.13
36.9	1.00	-3.43	1.05	1.00	-0.68	-13.44
37.5	1.00	-1.23	-0.45	1.00	0.24	-16.22
38.1	1.00	-1.34	-6.32	1.00	0.52	-18.22
38.7	1.00	-1.06	-5.40	1.00	0.95	-16.70
39.3	1.00	-0.01	-2.99	1.00	1.22	-15.16
39.9	1.00	0.21	-5.24	1.00	0.92	-13.14
40.6	1.00	0.26	-9.72	1.00	0.68	-10.83
41.2	1.00	0.35	-14.09	1.00	0.93	-8.96
41.9	1.00	0.59	-15.43	1.00	1.03	-8.30
42.6	1.00	2.13	-11.76	1.00	0.99	-5.99
43.2	1.00	2.16	-9.68	1.00	1.54	-8.98
43.9	1.00	1.52	-8.24	1.00	0.18	-11.56
44.6	1.00	1.37	-8.83	1.00	0.81	-13.42

Table A-12
SUBJECT POOL MEAN ΔSBP (mmHg) AND ΔHR (bpm)
DURING FM MODIFIED L8 MANEUVERS

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
0.7	0.75	-0.30	-0.62	1.00	-0.64	1.09
1.3	0.57	-1.03	0.54	1.00	-1.24	0.06
1.9	0.65	-2.41	0.57	1.00	-1.37	0.02
2.6	0.86	-2.20	-1.23	1.00	-1.29	0.35
3.2	0.98	-0.71	-2.67	1.00	-2.02	-0.06
3.9	1.22	-0.42	-5.07	1.22	-1.49	-0.75
4.5	1.57	-1.73	-2.76	1.57	-2.42	0.66
5.2	1.87	-2.63	-0.73	1.87	-3.37	3.43
5.8	1.97	-2.38	3.59	1.97	-3.66	4.19
6.4	1.94	-2.68	5.54	1.94	-4.48	4.17
6.9	1.82	-1.87	5.74	1.82	-4.86	5.08
7.5	1.66	-2.70	5.55	1.66	-4.62	6.41
8.4	1.48	-2.94	6.29	1.48	-4.90	6.42
9.3	1.37	-2.47	6.81	1.37	-5.17	7.38
9.9	1.36	-3.33	8.15	1.36	-4.50	8.22
10.5	1.36	-2.14	8.71	1.36	-3.78	7.51
11.1	1.37	-1.60	6.38	1.37	-3.39	7.54
11.9	1.21	-1.43	4.07	1.21	-3.77	7.26
12.8	0.88	-2.25	2.25	1.00	-3.20	6.53
13.4	0.76	-1.52	-0.24	1.00	-2.82	4.99
14.0	0.64	-1.44	-0.12	1.00	-1.77	3.81
14.6	0.47	-1.90	0.27	1.00	-1.33	0.87
15.4	0.03	-2.49	-5.61	1.00	-0.82	0.67
16.3	-0.37	-0.46	-0.74	1.00	0.00	-0.93
17.2	-0.68	-3.51	-14.27	1.00	0.49	-2.58
18.1	-0.95	-1.15	-15.06	1.00	1.65	-3.19
18.7	-1.00	-1.79	-26.52	1.00	0.80	-4.04
19.4	-0.31	0.30	-23.21	1.00	1.23	-2.99
20.1	-0.07	-1.30	-17.88	1.00	0.26	-3.32
20.8	0.52	-2.58	-14.40	1.00	0.53	-2.96
21.4	0.98	-3.59	-10.01	1.00	-0.05	-2.02
22.1	1.74	-5.78	-5.61	1.74	-0.57	0.86
22.7	2.38	-8.35	-1.67	2.38	-3.99	2.96
23.3	2.86	-11.36	6.36	2.86	-5.14	5.71
23.8	3.35	-12.76	11.98	3.35	-3.67	8.47
24.5	3.50	-13.67	13.85	3.50	-6.42	10.22
25.0	3.50	-13.05	15.61	3.50	-6.77	12.04
25.5	3.50	-13.54	16.24	3.50	-7.64	15.09
26.4	3.50	-14.69	18.40	3.50	-9.91	16.17
27.2	3.50	-14.86	23.26	3.50	-10.64	18.23
27.7	3.50	-14.32	20.90	3.50	-10.75	17.09
28.5	3.50	-13.91	23.98	3.50	-12.33	19.92
29.3	3.50	-13.18	22.40	3.50	-12.53	23.61
29.8	3.23	-12.91	25.96	3.23	-13.13	22.25
30.1	3.10	-12.94	23.72	3.10	-11.22	24.43
30.3	2.98	-12.72	25.29	2.98	-10.05	25.31
31.1	2.60	-11.03	27.59	2.60	-8.80	23.48

Table A-12 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
32.0	2.50	-10.44	24.04	2.50	-8.76	20.63
32.8	2.86	-8.92	18.92	2.86	-5.67	18.84
33.2	3.10	-8.35	22.73	3.10	-5.07	18.09
33.7	3.34	-8.91	22.36	3.34	-4.90	16.92
34.2	3.50	-9.66	23.98	3.50	-5.19	16.89
34.7	3.50	-11.32	25.71	3.50	-5.91	19.52
35.1	3.50	-11.66	27.79	3.50	-5.64	20.37
35.8	3.25	-10.18	30.06	3.25	-5.65	19.38
36.7	2.92	-8.67	31.47	2.92	-6.59	21.76
37.3	2.68	-8.26	30.76	2.68	-5.86	21.63
37.7	2.51	-7.97	29.14	2.51	-4.47	20.47
38.2	2.35	-6.62	30.67	2.35	-3.01	21.44
38.6	2.19	-5.48	28.81	2.19	-3.06	21.23
39.0	2.03	-5.11	28.67	2.03	-3.32	21.23
39.5	1.86	-4.77	27.49	1.86	-3.03	19.35
40.2	2.15	-2.51	25.97	2.15	-1.73	20.35
40.9	2.45	-0.95	23.00	2.45	-0.27	19.87
41.4	2.65	-0.70	23.13	2.65	-0.31	17.97
42.3	3.03	-0.72	20.22	3.03	-0.78	16.37
43.2	3.42	-1.14	20.38	3.42	-1.89	16.80
43.6	3.61	-1.76	20.37	3.61	-2.32	18.26
44.1	3.81	-3.30	21.94	3.81	-4.03	19.00
44.6	4.00	-3.88	22.89	4.00	-5.95	20.92
45.0	4.19	-5.25	23.50	4.19	-8.72	21.69
45.5	4.37	-9.09	26.55	4.37	-13.03	24.58
45.9	4.50	-12.57	27.52	4.50	-10.68	24.56
46.3	4.32	-12.56	29.02	4.32	-11.34	26.20
46.8	4.13	-12.02	32.54	4.13	-11.60	28.22
47.2	3.96	-11.66	32.04	3.96	-10.96	27.32
47.9	3.70	-10.29	34.32	3.70	-11.28	28.78
48.5	3.44	-8.41	30.71	3.44	-10.36	29.68
49.0	3.26	-9.09	31.92	3.26	-8.68	28.59
49.4	3.08	-7.33	32.36	3.08	-8.16	29.02
49.9	2.90	-3.88	28.09	2.90	-6.56	29.71
50.6	2.63	-2.91	23.77	2.63	-4.28	25.80
51.2	2.36	-2.06	16.60	2.36	-3.71	23.51
51.7	2.18	-0.46	16.25	2.18	-2.33	19.99
52.2	1.99	-0.76	16.90	1.99	-1.87	19.41
52.6	1.94	0.30	16.50	1.94	-1.06	14.03
53.1	1.90	1.05	13.87	1.90	0.19	12.62
53.8	1.83	1.25	12.67	1.83	1.09	10.22
54.7	1.73	1.83	11.86	1.73	2.45	8.70
55.5	1.66	2.99	11.22	1.66	2.99	9.63
56.2	1.59	2.63	9.21	1.59	3.05	8.57
56.9	1.52	1.85	6.14	1.52	3.25	7.92
57.4	1.47	3.01	5.65	1.47	3.29	7.82
57.9	1.42	1.82	5.44	1.42	3.43	8.93
58.6	1.35	1.89	7.24	1.35	2.61	7.74
59.3	1.28	1.90	8.62	1.28	2.50	7.56

Table A-12 (Cont'd)

	PPM			GM		
Time (sec)	Gz	ΔSBP	ΔHR	Gz	ΔSBP	ΔHR
59.8	1.23	2.42	8.32	1.23	3.14	5.68
60.9	1.12	2.01	6.69	1.12	4.02	5.04
61.7	1.03	2.52	6.86	1.03	3.43	4.84
62.2	1.00	2.20	5.78	1.00	3.37	4.78
62.7	1.00	2.01	3.83	1.00	2.96	3.08
63.2	1.00	2.50	2.03	1.00	3.53	2.54
63.7	1.00	2.82	1.23	1.00	3.21	0.67
64.2	1.00	2.39	-3.48	1.00	2.66	0.03
64.7	1.00	2.74	-0.95	1.00	2.91	-0.72
65.2	1.00	2.58	-2.71	1.00	3.04	0.40
65.7	1.00	2.42	-1.56	1.00	3.64	0.40
66.2	1.00	1.71	3.30	1.00	2.50	-3.35
66.7	1.00	0.06	6.66	1.00	3.07	-2.94
67.2	1.00	0.49	-0.22	1.00	2.58	-2.91
67.7	1.00	1.74	-1.83	1.00	2.01	-3.50
68.2	1.00	1.60	-1.63	1.00	1.80	-2.74
68.7	1.00	2.29	-0.64	1.00	2.15	-3.87

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